EDITION B

DETROIT

The Journal of the INSTITUTION OF PRODUCTION ENGINEERS

Vol. XXII No. 4

APRIL, 1943

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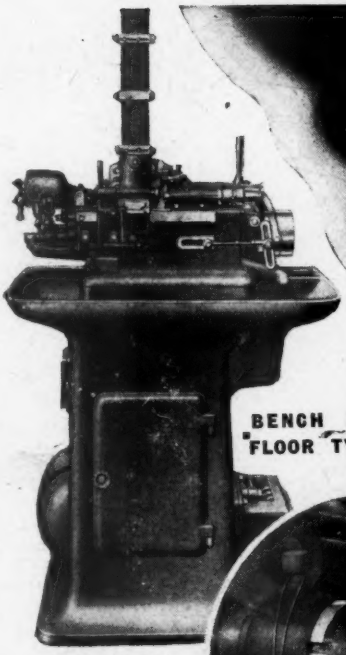

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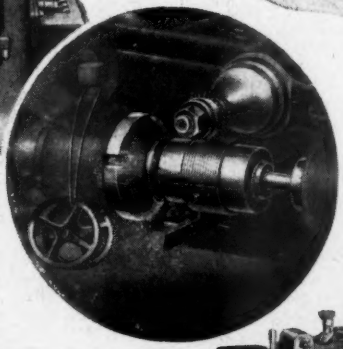

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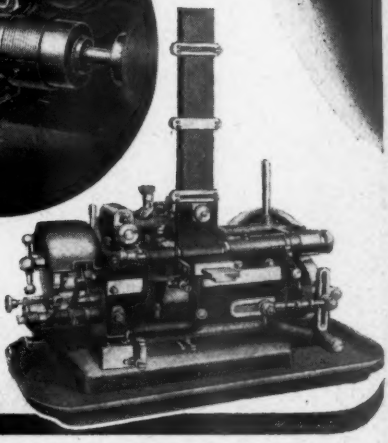

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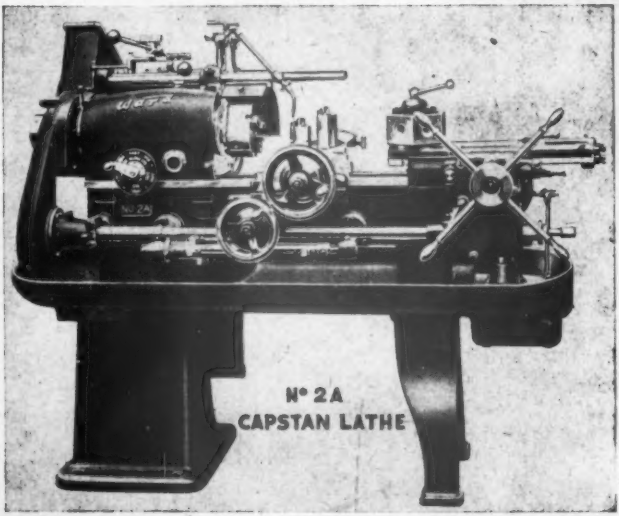

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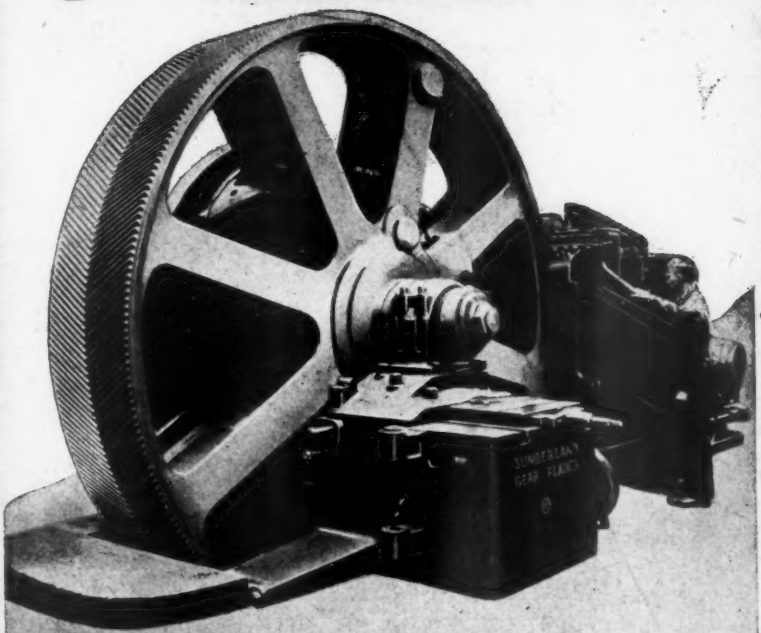

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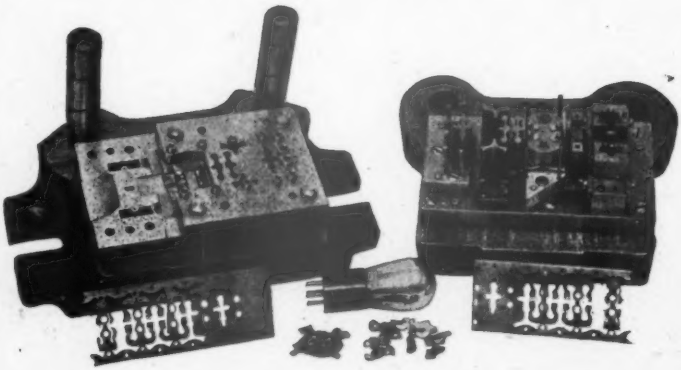

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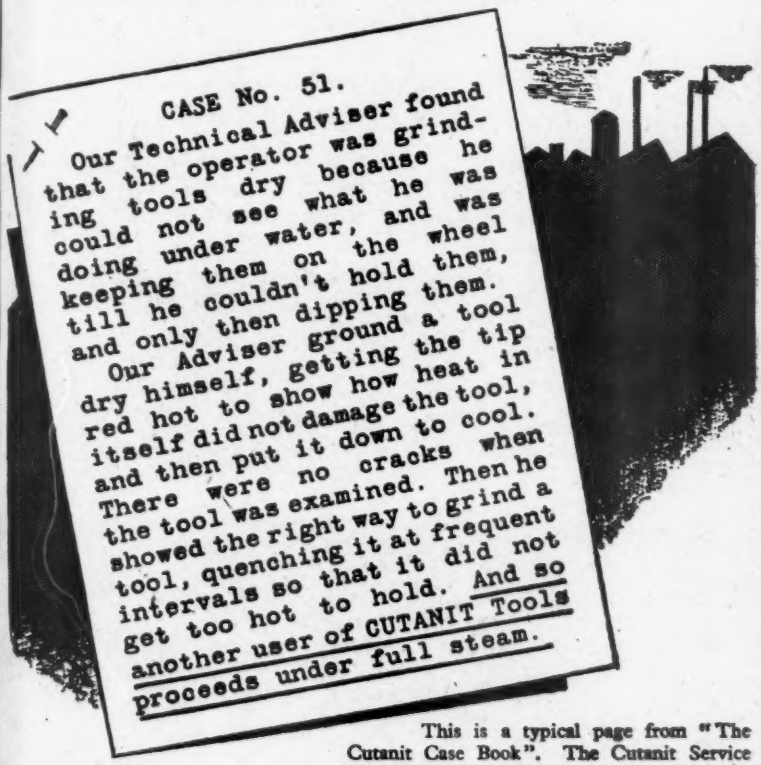
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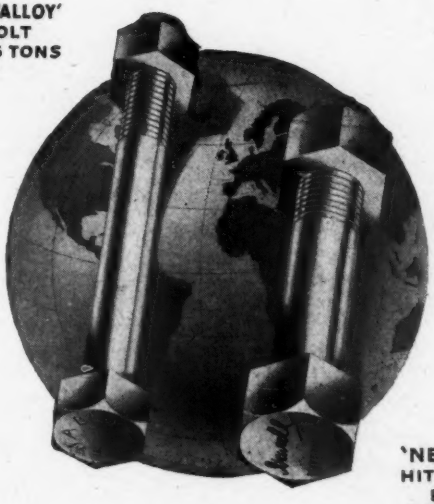

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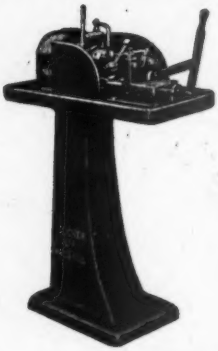

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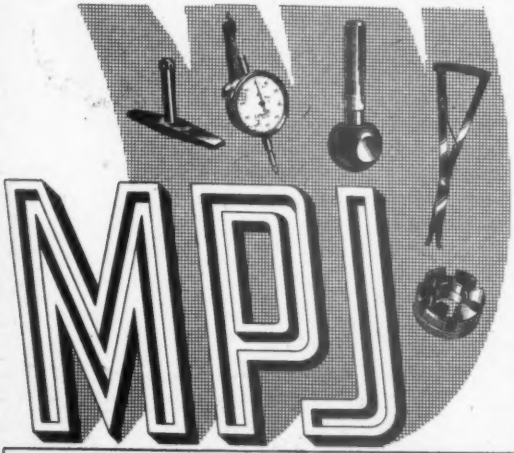

M.P.J.

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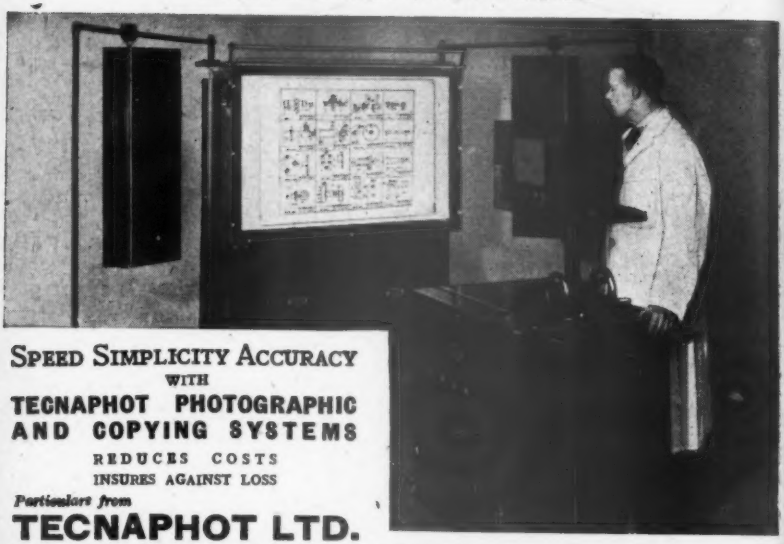

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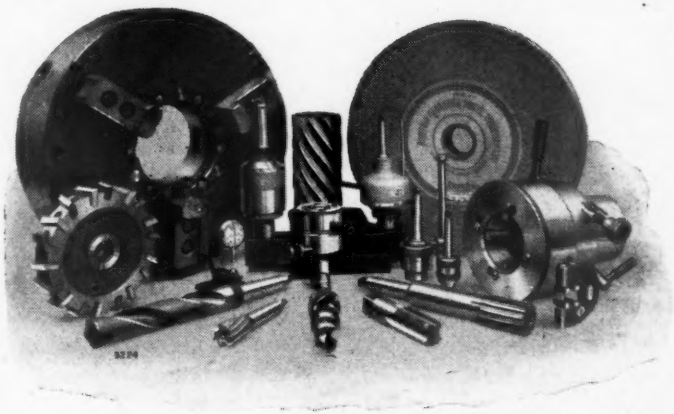

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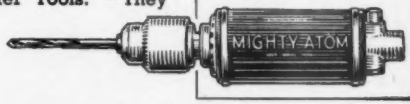

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C.R.C. 126

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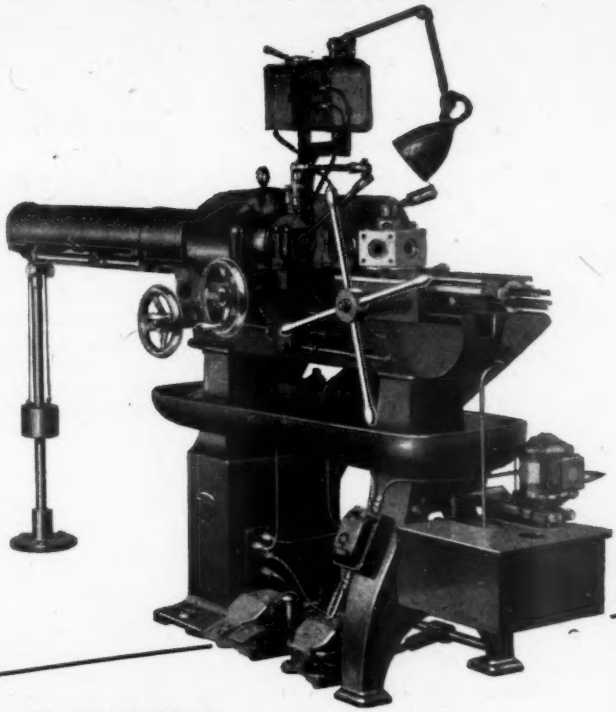
The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.



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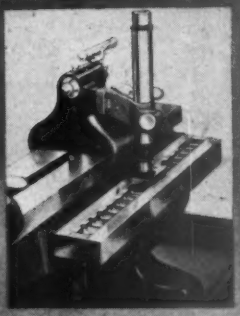

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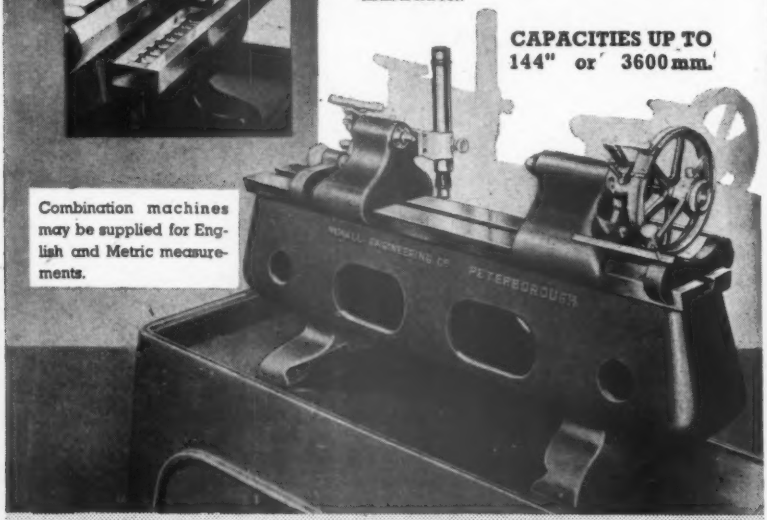

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THE LATE RICHARD HAZLETON
General Secretary 1921-1943

THE LATE GENERAL SECRETARY

At the Council Meeting held on March 19, 1943, the following Resolution was passed :—

> The Council records with profound regret the death of Richard Hazleton, the General Secretary, and in paying tribute to the memory of an esteemed friend and honoured colleague, acknowledges the debt which it owes to a great man with a great mind and a great personality who, having declared his faith in the Institution with which he identified himself completely, lived with it and for it throughout his fifteen years of arduous endeavour from which the Institution has derived incalculable benefits. By his skilful leadership, clean courage, supreme confidence, forgetful self-devotion, and the tremendous sanity of his grasp of the problems which continuously confronted him, Richard Hazleton was able to inform the machinery of the Institution with the flame of his own spirit, and to secure the foundations on which have been built up the enhancement of prosperity and the Institution's welfare.

The Institution mourns the death of its General Secretary, Richard Hazleton ; a great man with a great mind and a remarkable personality who spent many years of arduous and persistent endeavour from which immeasurable advantages and benefits have accrued to the Institution.

When Richard Hazleton was appointed to the office in 1929, the Institution was in its infancy. His adaptability and fitness for the position were soon confirmed and he filled it with an ever-increasing recognition in all quarters of his unique qualifications. The more one knew of him the more one became aware of his rare endowments. From the outset he identified himself completely with the Institution, lived with it and for it, and seeing the shape of things to come, and how vital a contribution Production Engineers would be called upon to play in the struggle that was envisaged by the long-sighted, Richard Hazleton strove to make the Institution a nationally important and indispensable agency working for the efficiency and welfare of industry. His abilities soon gained for him a position of influence with Production Engineers, and his wide experience of public life, his knowledge of how to handle men, to prepare a case and speak thereon, proved of inestimable value in establishing the Institution as a national organisation in the fullest

sense. It is largely due to his untiring efforts that the Institution has made such consistent and onward progress and has increased its membership fifteenfold. Richard Hazleton was, in fact, in every way the ideal General Secretary, and a first-class organizer, and leaves behind him a living memorial that he played so dominant a part in building-up—The Institution of Production Engineers, whose national and domestic policy he steered so skilfully to its widely acknowledged position of influence and importance.

He was responsible for continually focussing the attention of members on the value of research, and played a prominent part in creating and developing the Research Department housed at the Loughborough Technical College, an activity the excellence of which is the touchstone of any Institution.

Richard Hazleton was a man of great character. His aims, his ideals, his points of view, his enthusiasms and his hostilities were such that those who had the privilege of knowing him intimately could understand and entertain. He was without fear, free from affectation, always alert, with few hesitations and few regrets. As a companion he was ever delightful and stimulating; warmhearted, generous, staunch in friendship, and of sterling integrity, completely disdainful of self-interest and courageous in his courteous candour. He never for a moment shirked his duty, but often laboured on under anxiety and strain, and even after he was striken down in the midst of his work his interest in the conduct and welfare of the Institution continued to the end.

Richard Hazleton dies lamented and certainly not to be forgotten. His example, his fortitude, his faith, will continue as an incentive and inspiration for the guidance of those who carry on the vital work for which he gave his life, and as a basis for the better and greater Institution which is yet to come.

INSTITUTION NOTES

April, 1943

Fixtures.

April 21—London Section. A lecture will be given at the Institution of Civil Engineers, Gt. George Street, S.W.1, at 7 p.m. on "Production Control" by R. Appleby, A.I.P.E. (Ministry of Production.)

April 30—North Eastern Section. The lecture, which was to have been held at the County Hotel, Newcastle-on-Tyne, on "Surface Finish, with Applications to Practical Problems" by Dr. Geo. Schlesinger, has been cancelled.

May 14—Preston Section. Annual General Meeting at 7 p.m. at the Royal Oak Hotel, Chorley.

May 21—A meeting will be held at the Institution of Mechanical Engineers on Friday, May 21, at 5-30 p.m., when a paper on "Surface Finish and the Function of Parts" by G. Schlesinger will be presented for discussion. Advanced copies of the paper may be obtained from the Secretary of the Institution of Mechanical Engineers.

The Council of the Institution

APRIL, 1943

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HIGH SPEED IN THE WAR TIME PRODUCTION SHOP*

By G. Schlesinger, Hon.M.I.P.E.,
Director of Research

THE simplest means to increase output in the workshop without adding expensive equipment seems to be the introduction of super high speed steel cutting tools and cemented carbides. Then only the existing ordinary carbon (tap) or 18%W cutting tools must be changed for another fairly inexpensive set of tools. The main problem seems to be solved; but this solution is not so simple as it sounds. The introduction of cemented carbides particularly into the ordinary workshop depends on the possibility to increase the speed and power of the machine tools; otherwise the result will be

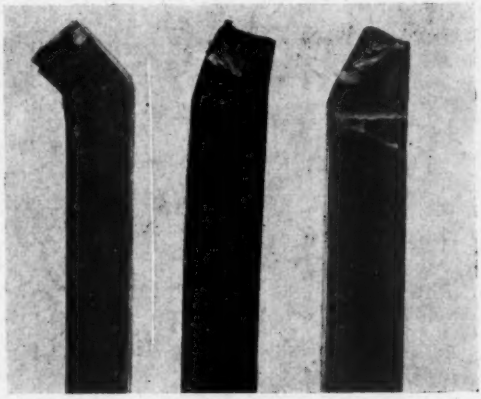
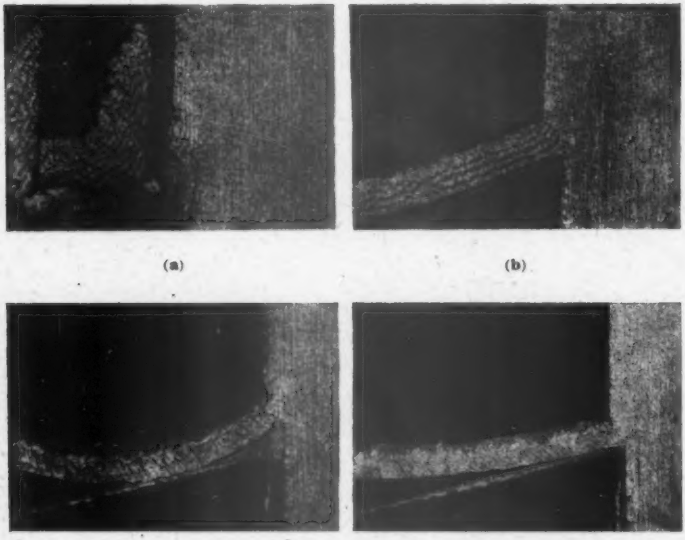


Fig. 1.—Destroyed carbide tipped tools.

broken tools (Fig. 1). It is useless to try to introduce cemented carbides if it is possible that the machine tool may be stopped either by a slipping belt or clutch, or a stalled motor. Why is the tool destroyed if the main spindle is stopped? The cutting forces on the tool are not increased because the cross-section of the chip remains

* Paper read before the Yorkshire and Luton Sections of the I.P.E.

the same whether the machine runs at 1500 r.p.m. or 10 r.p.m. It is the design of the machine tool which causes the destruction. If the feed could be stopped exactly at the same time as the rotating movement of the spindle, nothing would happen. But if the feed moves the tool along only a thousandth of an inch or less, the brittle cemented carbide tool is twisted and, as it has no elongation, is smashed. In all lathes the amount of power consumed by the feed is very low—it is between 1 and 3% of the total power consumption, therefore the very small movement produced by the inertia of the rotating parts between mainspindle and carriage suffices to perform that little destructive twist. If there is a friction clutch between the feed drive and the main spindle drive, this detrimental



(a) (b)

(c) (d)

Fig. 2.—(a to d) Tear (a, c) shear (b) flow (d) chips.

(a) *Tear Chips*. Formation of soft steel chip produced by tool having incorrect angle. (Tool angle 80°).

(b) *Shear-Chip* (slow speed). Formation of soft steel chip produced by tool having correct angle. (Tool angle 65°; other conditions identical).

(c) *Tear-chip* (built-up edge). Formation of steel chip at low speed (65 feet per minute).

(d) *Flow-chip* (high speed). Formation of steel chip at high speed (366 feet per minute, other conditions identical).

movement always occurs. It is further necessary that cemented carbides work with high speed (from 120 feet/min. upward) to overcome irregularities, to secure a flowing chip and to avoid tear or shear chips which are frequently produced by the ordinary high speed tools. The well known illustration (Fig. 2) explains our problem admirably. Fig. 2 (a) shows the formation of soft steel chips produced by a tool having an incorrect angle. If the angle for cutting soft steel is changed from 80° to 65°, the chip changes to the shear type (b). Another danger is the built-up edge (c : tear and shear combined) which is formed by cutting dry at rather low speed (65 feet/min.) and is eliminated at high speed (355 feet/min.) flowing chip (d) using a fatty lubricant.

A belt drive is only reliable if the belt speed is above 1200 feet/min. —it would be even better to design the machine for 1500 feet/min. belt speed or more. A narrow quick running belt is much superior regarding its driving reliability to a wide slow running belt. Then the advantage of the belt drive, which consists in the noiseless action of a power carrying element, improved with increasing its speed, is completely exploited.

The machine tool designer must know and use correctly all factors of drive and machining : cutting forces, torque, cutting speed, spindle revolutions, which are combined as :

(1) Forces $\times$ speed ($P = F \times v$), and

(2) Torque $\times$ revs. ($P = M \times n$).

They must be correctly distributed on : the machine tool, the tool and the workpiece to reduce deformation, vibration and heat to a minimum. Their relations between each other and the reciprocal influence of tool on specimen must be well known both by the designer and by the user in the workshop. If all these conditions are studied well, cemented carbide tipped tools can safely be used as single point cutting tools for lathes and planers, and as multiple-tipped tool : drills, counter-bores, reamers and milling cutters. But in a great many cases the design of the machine tool is far behind the development of modern cutting tools. We were too conservative for many years before the war—the commercial administration kept the old equipment as long as possible and now during the war we can " increase the output of the workshop without increasing equipment " only by correct rebuilding of the existing machine tools to achieve the changed workshop conditions unless it is possible to purchase new machines. Even if new machines can be obtained they do not always achieve the increased requirements covered by the ominous inscription " war-finish." As far as this means rough painting and rough cast surfaces the specification can be accepted but if the design is poor, the workmanship decreased, and the performance inadequate, we shall never get an increased output.

Quantity first is not sufficient. Components for aircraft, tanks, lorries, guns and ammunition require high quality tools. In most cases the parts must be interchangeable, yet manufactured by semi-skilled male or female operators who cannot equalise the errors of inaccurate machine tools by skilled craftsmanship. The performance of a well made and accurate machine tool operated by a female worker is always superior to that of an obsolete or worn-out machine tool operated by the most skilled craftsman ; and it is more economical.

A certain danger in using super high speed or cemented carbide tipped tools is the handling of the swarf. If the tool is correctly

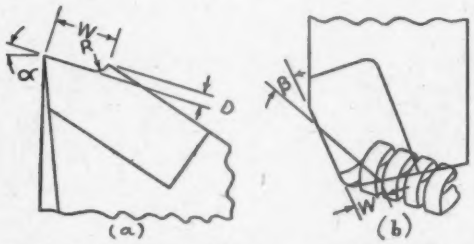


Fig. 3.—(a. b). Correct chip breaker grooves ; front width (W), depth (D), radius (R), inclination of bottom (α) of groove (β).

ground and made, the dangerous swarf is transformed to the uniformly flowing quiet chip which can easily be handled and does not endanger the workman on the machine. The solution of this problem is the chip breaker groove directly ground into the surface of the tool, achieving the following conditions [Fig. 3 (a), (b)].

1. Contour of chip control groove must be made to deflect easily steel chip into a coil. The groove contour consists of a flat, blending into a radius. The flat is diamond ground at an angle corresponding to the top side rake or slope best suited for the steel to be cut. This angle is angle " α " shown in Fig. 3 (a).

The width of the groove " W " (flat + radius) determines the diameter of the coiled chip. This groove width is affected by the feed per revolution, and the steel being cut.

The radius " R " effectively deflects the chip into a coil. This radius varies chiefly with the feed per revolution. Usually, for best results, the following radii are recommended : up to .010in. feed—$^{1}/_{16}$in. radius ; from .010in. to .030in. feed—$^{3}/_{32}$in. radius ; from .030in. to .050in. feed—$\frac{1}{8}$in. radius ; above .050in. feed—$^{3}/_{16}$in. radius.

The depth of groove " D " must be sufficient to deflect the chip

into a coil. Usually a $^1/_{64}$in. depth is sufficient for feeds up to .010 in. ; $^1/_{32}$in. depth, for feeds up to .030 in ; and $^3/_{64}$in. to $^1/_{16}$in. depth, for feeds above .030in. It is recommended not to allow " D " to become greater than $^1/_{16}$in. deep.

2. Generally, the chip control groove should not be parallel to the cutting edge. The top view of the chip control groove should be in the shape of a triangle, the radiused side of the groove forming an angle " a " to the cutting edge. The amount of this angle, determines the direction of chip flow. This type of groove usually throws the coiled chip in the direction shown in Fig. 3 (b). When chips are directed as shown, the chip does not injure the cutting edge, nor can the chip gouge out the shank directly under the tip. This type of groove usually directs the coiled chip into the work, and this action breaks up the chip into coils of short length.

3. Once the end contour, and top shape of the groove have been determined, they must be duplicated exactly to maintain efficient operation. This cannot be done by free hand grinding. The chip control groove cannot be safely produced on a surface grinder, because of the danger of breaking the tip, due to excessive down-feed.

High speed requires a bigger motor directly proportional to the increase of speed. This involves the danger that the operator using an ordinary high speed tool or a substitute " 66 " or " 46 " which cannot withstand high speed is decreasing the speed but increasing the section of the chip at the same time to keep up the weight of chips produced per hour, so maintaining the same output as before—and his bonus. However, this method increases the stress on the driving gears and machine elements.

By the decree of the Ministry of Supply in February last year we are not allowed to use tungsten steel alloys with more than 6.5% tungsten, therefore the British tool industry accepted the American tool alloy " 66 " (now replaced by " 46 ") which gets its name from the combination of 6% tungsten plus 6% molybdenum (now 4% Mo with 4% Cr and 1 to 1.5% Va). Hardening and tempering conditions of the " 66 " substitute are given in the table (Fig. 4). Substitute " 46 " should be treated in the same way.

The Research Department had to test these tools and can confirm that the efficiency and output is the same as the 18%W. high speed tool using the above mentioned specification. The decarburised zone is avoided—there is no difficulty even for making taps work with no more than .010 in. material allowance for grinding sharp. The table (Fig. 5) shows comparison tests which we made with tools of both 18% tungsten and " 66 " material.

Tests **1** *and* **2** : Substitute " 66 " (MA8) did not stand 259 f.p.m. as well as the 18% Tungsten tool (SA3) with approximately the same

surface roughness 130/162 mu in. against 110/150 mu in. We have for one hour's test 46.5 in. length (Test 1) with 18% tungsten tool against 20.2 in. length (Test 2) with "66" on normalised steel of 35 to 40 tons/sq. in. tensile strength. The speed must be decreased for the "66" from 259 f.p.m. to 116 f.p.m.

Tests 3 *and* 4: Substitute "66" (MA10) had the same output in length, time and approximate quality as the 18% tungsten tool (SA3) for the fairly high speed of 213 f.p.m. on hard and tough manganese steel of 60 tons/sq. in. tensile strength.

Obviously brand MA10-"66" was better than MA8-"66."

Tests 5 *and* 6: Substitute "66" (MA3) had the same output and surface quality as the 18% tungsten tool (SA3) for the same

No.	Operation	Temperature Degrees	Time min.	Remarks
1	Pre-heating	400-500	15-30	On top of a hot furnace or in the hot air-furnace before putting the tool into the pre-heating salt-bath (op. 2).
2	Pre-heating	850	15 (minimum)	Salt bath time depends on the size of job: The colour is uniform through the mass.
3	Full-heating	1260	From ½ to 5 min.	No exact time limit possible according to size of job.
4	Quenching	560	10-15	By putting big hot (1260°) tools to the quenching bath, its temperature is raised and must cool down again to 500°.
5	Tempering	580	120	Directly from quenching to tempering salt-bath.
6	Final cooling	580	60-120	In air.

Tools treated like this have no decarburised skin. They are ground with the ordinary material allowance of 0.010 in. and get a Rockwell Hardness C. of 63 to 64.

After the final cooling down to room temperature and after the tools have been washed and freed from the salt, a second tempering for 3 hours at 200° C. is advisable in the hot air circulating furnace. After this the tools are sand blasted and finished by sharp grinding.

Fig. 4.—Hardening Prescription for "66" material using a salt bath of Chlor-Barium Potassium Chloride.

fairly low speed of 105 f.p.m. on chromium-nickel steel of 80 tons/sq. in. tensile strength.

Conclusion: The efficiency of Substitute "66" tools will be the same as that of good 18% tungsten tools, if the heat-treatment of "66" is correctly done. Test 2 with MA8 seems to prove that. The "66" tool cut less than half the length 20.2 in. against 46.5 in. and failed in spite of the speed reduction from 259 to 116 f.p.m.

The cutting angles must be very carefully selected according to the material and checked by simple gauges (Fig. 6a-c) which allow you to control quickly the rake, relief and clearance angles all over the

Test No.	Material: Specimen	Material: Tool No.	Material: Tool Steel	Radius Tip in.	Angles: Plan: Approach deg.	Angles: Plan: Wedge deg.	Angles: Side-Section: Rake deg.	Angles: Side-Section: Wedge deg.	Angles: Side-Section: Relief deg.	Speed: Outs dia. in.	Speed: RPM	Speed: FPM	Feed in.	Depth in.	Coolant	Surface Finish h_{ave} mu in. Axial distance from tailstock end: 1"	5"	10"	15"	20"	30"	40"	45"	50"	60"	65"	Length of Total cut in.	Cutting time min.
1	Mild Steel 35 to 40 tons tensile	SA3	18% Tungsten	.040	60	90	5	80	5	6½	150	259	.005	.010	dry	130	120	150	135	160	160	162					46.5	60
2		MA8	"66"	.040	60	90	5	80	8	6½	68	116	.005	.010	dry	110	110	200	110	150	–	–					20.2	60
3	Manganese steel 60 tons/ tensile	SA3	18% Tungsten	.040	30	95	4	78	8	11⅞	66	213	.004	.008	dry	124	170	240	220	–	–	–					15.9	60
4		MA 10	"66"	.040	30	95	4	78	8	11⅞	66	213	.004	.008	dry	120	280	300	200	–	–	–					15.9	60
5	Cr-Ni steel 80 tons/ tensile	SA3	18% Tungsten	.040	60	90	5	80	5	9⅛	42	105	.004	.008	dry	95	95	90	64	68	60	70	65	68	80	120		370
6		MA8	"66"	.040	17	90	5	80	5	9½	42	105	.004	.008	dry	135	78	78	63	90	70	62	59	70	52	95		370

Fig. 5. Finishing cuts. Comparison of the same well approved 18% Tungsten High Speed Tool (SA3). against three Substitute Tools "66" (MA8—MA10—MA3) on :

(1) mild steel of 35 to 40 tons/tensile.
(2) Manganese steel of 60 „ „
(3) Cr–Ni steel of 80 „ „

shop without using slow and expensive protractors. They cost very little and ought to be in the hands of all toolmakers who are entrusted to regrind the blunt tools.

Another important question is the rigidity of the complete tool. The maximum available shank section depends on the distance

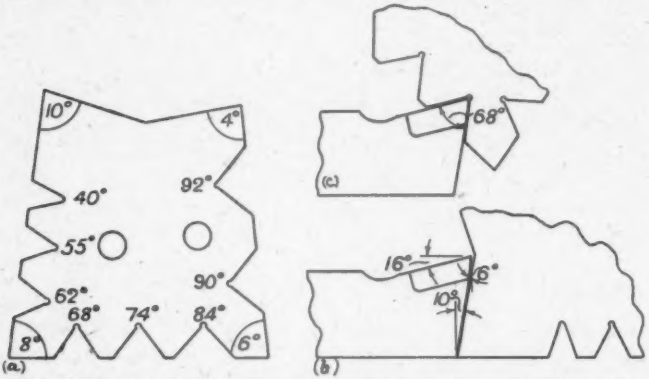


Fig. 6.—(a to c). Grinding gauges for angles of single point cutting tools.

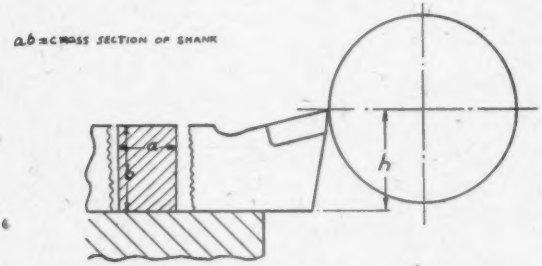


Fig. 7.—Distance between tool base and centre line (h).

between the centre line of the lathe and the base surface of the tool-post (Fig. 7) and ought to be as big as possible; it would help if the cross sections of the tool shanks were standardised* and if the shanks were made of good carbon steel or 80 tons/sq. in. tensile strength Cr-Ni steel for roughing cuts. For finishing tests a dense cast iron, *i.e.*, Meehanite, would be preferable—the damping action of dense cast iron is considerable and effective. Vibration in cutting is best avoided by a rigid and correctly ground tool.

* See proposals: Journal of I.P.E., Vol. XXI, February 1942, p. 82.

For all cutting tools on steel a sulphurised coolant is recommended because : (1) it cools the tool and specimen, and (2) reduces the friction between the chip and the tool surface eliminating the detrimental built-up edge [see Fig. 2 (c)]. Ample coolant supply, between 1 gallon and 4 gallons per minute depending on the cross-section of the chip, is useful for roughing and finishing cuts, on the condition that the first movement of the operator is to bring the

Tool	Material of specimen	dia. in.	speed fpm.	Cut		Area sq.in.	Gross input H.P.	Tangential cutting force lb.	Tool life min.	Index 1000 lb. per sq. in.
				depth in.	feed in.					
Cutanit Grade R	U-Material 60 tons Manganese steel	11	212	.156	.042	.0066	14.6	1460	62.5	223
Cutanit Grade S	do.	9.8	205	.5	.042	.021	45	4630	61.3	220
Cutanit Grade S	U-Material 80 tons Chrome-Nickel steel	7	170	.375	.042	.0157	25	3160	56.5	200

Fig. 8a

Fig. 8b. ANALYSIS OF RAW MATERIALS

Material	Dia. in.	C	Mn	Cr	Si	Ni	Mo	S	P	Brinell Hardness	Tensile Strength tons/sq.in.	Remarks
SM-Steel	8	.26	.65	–	.15	–	–	.03	.025	165	36 to 40	Heat treated (850°C)
Mn-Steel	12	.59	.80	–	.3	–	–	.04	.04	275	55 to 60	
Cr-Ni-Steel	8	.31	.57	.72	.21	2.74	.50	.032	.033	320	80 to 85	Heat treated

Fig. 8.—(a,b). Results of roughing tests(a) with cemented carbide tipped tools on SN—Mn—CrNi—Steels and analyses of steel (b).

Chrome-Nickel steel of 80 tons tensile is easier to be machined (1=200) than hard and tough Manganese steel of 60 tons/tensile. (1=220).

coolant to the tool before the cutting action commences. Otherwise the heated tool is cracked. This ought to be done with all operators. Capstan lathes and automatic screw machines are equipped for the use of coolants. The older lathe types must be provided with tray, strainer, suds pump and convenient piping.

Finally, it is necessary to guarantee good hardness of high speed tools which are hardened in your own tool room, *e.g.*, of "66" material. The minimum hardness is Rockwell 62C but 65C is preferable. However, this tool is more brittle and more easily broken if the

operator is careless by running the tool against a shoulder. A permanent control of hardness with the Vickers or Rockwell hardness tester is an excellent education for the tool room and pays in any case. It is remarkable how correct ratefixing, leaving a good bonus for the intelligent and skilful operator, reduces the number of destroyed tools. Tool destruction means a standstill of the machine, therefore loss of time, and the operator finds out very soon that his

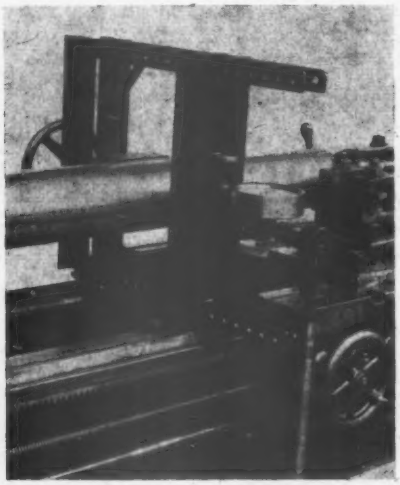
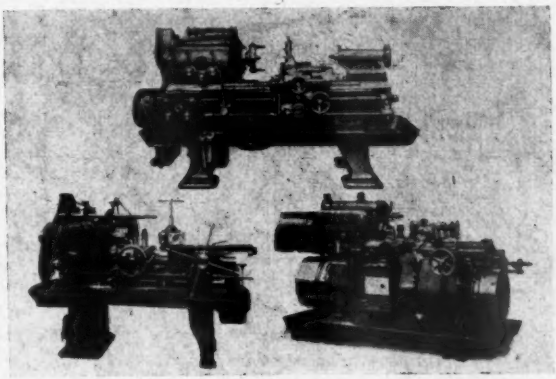


Fig. 9.—Transportable Brinell press mounted in a self contained frame.

earnings are dependent on sharp cutting edges and high speed tools. However, the workman must have full confidence in the uniform reliability of the tools supplied by the tool room.

Table Fig. 8 shows a short review on roughing tests of usual depth made by the Research Department with cemented carbide tipped tools on manganese and Cr-Ni steels used for highly stressed gears, crankshafts and similar important parts for the war effort. The last column shows the machineability-index for these materials which is of importance to get an idea of the cutting forces with which specimens made of these hard and tough materials between 60 and 85 tons sq. in. tensile strength are to best ressed. A quick test for the tensile strength, which can be estimated for steel by the Brinell hardness, is of importance. Since many lathe carriages are not strong enough to withstand the standard Brinell pressure of 3 tons in a horizontal plane, we made the transportable Brinell press

independent from the carriage and combined it with a simple frame so that the self contained apparatus could be easily adjusted for pieces between 2 in. and 20 in. diameter (Fig. 9). Since heavy roughing lathes, *e.g.*, of the low swing type, have very small centre heights—the frame of this Brinell press is so designed that it can slip into a gap of 2 in. between the external diameter of the piece



No. of pieces	1	1	1	10	10	10	100	100	100	1000	1000	1000
Machine Tool	Lathe	Capstan	Automatic	Lathe	Capstan	Automatic	Lathe	Capstan	Automatic	Lathe	Capstan	Automatic
Time in min.	75	180	-	38	80	-	35	10	5.3	-	-	2.8
Ratio of wage rates	1:1.5		-	1.9:1		-	7 : 2 : 1					
No. of pieces	10	10	10	100	100	100	500	500	500			
Time in min.	01	35	-	44	26	8.8	62.5	25.5	7.2			
Ratio of wage rates	3.8:1		-	7.9:3:1			8.6:3.6:1					

Fig. 10.—Economical comparison between centre lathe, capstan and automatic screw machine.

and the lathe bed. The entire arrangement is light in weight and very easy to handle. By the ratchet lever in front any operator can easily exert the 3 tons necessary for the Brinell indentation.

The full use of semi-skilled male and female labour is invariably bound to accurate, quick and powerful machine tools. A look at the ordinary equipment shows in a good many cases that this is a problem which can only be solved with great difficulty. Large

batches or quantity manufacturing ask for modern capstan and combination turret lathes and automatic single or multiple spindle screw machines, which obviously beat the strong and accurate lathe, shortening the time and increasing the output by using semi-skilled labour (Fig. 10).

It is possible to improve old machine tools, if they undergo a real "rebuilding" and not an ordinary reconditioning. Scraping the slideways re-establishes the alignments and replacing the bearings and gears improves the accuracy, but this is not adapting an old machine design to modern requirements. The headstock (Fig. 11) of a 29 years old lathe was reconditioned in the following way. The small drop oilers were replaced by big ones. The lubricating effect of the oil itself was improved by adding 15% colloidal graphite. The front bronze bearing was babbitted, the oil grooves were removed, and the oil supply was changed from the

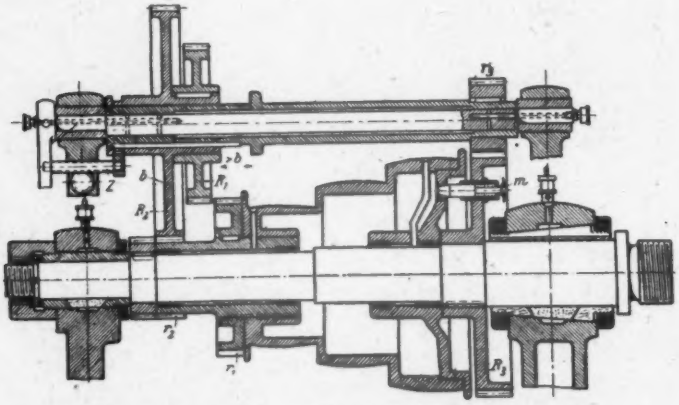


Fig. 11.—Section through belt driven headstock of rebuilt old lathe.

top to the side, at the point of lowest pressure. The plain thrust fibre washer was replaced by a selected thrust ball bearing with .0001 in. camming action only. The small cast iron pinion r_3 was replaced by a steel gear and the cast iron bull gear by one of dense cast iron. The most important thing was that the main spindle together with the cone, the gears and the one sided pin clutch were balanced for high speeds (350 to 700 r.p.m.). This machine ran before with 220 r.p.m. maximum. It has been running now for 18 months without interruption up to 700 r.p.m. We had not a

single failure. This is "rebuilding," and the changes described depend, of course, on the design of the existing machines. By increasing the speed from 220 to 700 r.p.m. (more than three times) the belt velocity rose to 1500 f.p.m., instead of 500; this is very favourable to belt drive. At the same time the power drive of the machine increased from approximately 4 to 12 h.p. Using this machine we took care not to increase the force F, because we could not change the strength of the teeth of the driving gears, but we trebled the speed to be able to use the SHS-steels, Stellite and cemented carbides. Naturally the operator must be informed that he

INDUSTRIES		FINISHING OPERATION					
		Grinding	Turning	Diamond Turning	Lapping	Boring	Milling
1. Automobiles	No. of Surfaces	32	8	4	8	1	8
	Ave. mu in.	18	85	26	6	66	77
	Max. „ „	51	209	55	15	–	115
	Min. „ „	3.2	12	15	1.5	–	12
2. Buses and Lorries	No. of Surfaces	64	21	–	4	5	2
	Ave. mu in.	18	85	–	2.7	79	81
	Max. „ „	51	215	–	3.3	181	129
	Min. „ „	3.7	13	–	2.3	15	34
3. Aeroplanes	No. of Surfaces	18	8	6	7	1	1
	Ave. mu in.	14	28.8	8.4	1.7	3.4	23
	Max. „ „	30	17	17	3.5	–	–
	Min. „ „	1.5	2.6	2.6	.98	–	–
4. Electrical	No. of Surfaces	14	3	–	1	–	1
	Ave. mu in.	19	44	–	27	–	13
	Max. „ „	26	84	–	–	–	–
	Min. „ „	9.6	9.6	–	–	–	–
5. Machine Tools	No. of Surfaces	33	2	–	–	–	–
	Ave. mu in.	15.5	47.5	–	–	–	–
	Max. „ „	52	62	–	–	–	–
	Min. „ „	2.2	33	–	–	–	–
6. Gauges (Excluding Slip gauges)	No. of Surfaces	9	–	–	21	–	–
	Ave. mu in.	8	–	–	1.32	–	–
	Max. „ „	25	–	–	2.9	–	–
	Min. „ „	1.8	–	–	.5	–	–
7. Slip Gauges	No. of Surfaces	–	–	–	25	–	–
	Ave. mu in.	–	–	–	.44	–	–
	Max. „ „	–	–	–	.5	–	–
	Min. „ „	–	–	–	.37	–	–

REVIEW OF ROUGHNESS

Fig. 12.—Commercial Finish in British Industries.

is not permitted to increase the cross-section of the chip because he has now a sufficiently big motor to smash the gears. He must learn that speed consumes power without increasing the forces. In the power formula of the lathe $HP = \frac{\text{Force} \times \text{speed}}{33{,}000 \times \eta}$; force and speed are of equal influence.

A well rebuilt lathe can produce surface quality within the fine limits of commercial grinding easily between 16 and 32 micro-inch (mu in.) and even down to 8 mu in. of fine grinding. The review* of commercial roughness for finishing operations, shown in Fig. 12 for grinding, fine turning, diamond turning and lapping, proves that the big British industries of automobiles, buses and lorries, aeroplanes, machine tools, electrical machinery, are using as an average surface finish of approximately 18 mu in. for grinding and that the average for fine diamond turning for good aero-engines is not finer than 8 mu in. Perfect alignments and levelling are the indispensable basis for the success of reconditioning. Table (Fig. 13) shows the finishing results which we had on the above mentioned reconditioned lathe with cemented carbides on steels, tough copper,

Specimen	Tool	Speed FPM.	Feed in/rev.	Depth in.	Coolant	Surface finish have mu in.
(1) Mild steel—36 tons/sq.in. tens.	Carbide 22	392	.004	.008	no	44
(2) Chrome-Nickel steel. 80 tons/sq. in. tensile.	Carbide 7	376	.002	.004	no	32
(3) Copper—99.8% Cu. (tough-pitch)	Carbide 21	588	.0025	.003	1:25	13
(4) Brass casting 58 Cu—39.5 Zn—2.5 Pb.	Carbide 4	860	.0005	.003	no	11.3
(5) Aluminium alloy casting.	Carbide 24	1200	.0005	.003	no	13

Fig. 13.—Finishing test with rebuilt lathe on (1 and 2) steels, (3) copper, (4) brass, (5) Aluminium alloy.

and the ordinary brass and aluminium alloys. To secure the adjustments of depth the cross dial of a well designed lathe should allow 0.001 in. per division. Otherwise a dial indicator of .0001 in. should be used to control the cross movement. With a fine chip of .003 in. depth and .002 in. feed, a good modern lathe using cemented carbides ought to compete with the grinding machine, both by surface quality and in dimension without using a file or emery cloth, even operated by an intelligent and attentive female operator instead of the craftsman. The degree of surface fineness could be produced approximately to the following scale :

Commercial (fine) finish .... 8.1 — 16 micro-inch.

Ordinary commercial ... 16.1 — 32 „

Rougher than 32 is a pre-finished surface which may vary between

* Comp. "Surface Finish," Report of the Reseach Department of the I.P.E., p. 31.

32.1 to 63 mu in. Above 63 mu in. roughness a final finishing operation is required.

It is useful to compare the tolerances for standard holes, class B (most accurate fit) with the pitch of the feed for the finishing operations and with the depth of the surface ridges which determine the quality of finish (Fig. 14).

For big high speed machine tools with main spindles, the front diameter of which is bigger than 4 in., it is not advisable to use plain bearings of the ordinary but never obsolete design (Fig. 15),

Cross-section of Chip							Tolerances for most accurate standard holes (class B) inches	
Finishing Operations	Feed inches		Depth inches		Depth of surface irregularities mu in. (ave)*			
	from	to	from	to	from	to	Dia. of hole	Maximum tolerance
Finish turning	.002	.006	.003	.010	25	125		
Diamond turning and boring	.0005	.003	.002	.008	3	25		
Commercial grinding	.0002	.003	.0006	.002	16	32	.25	.0003
Fine grinding	.0001	.002	.0003	.001	2	8	.5	.0004
							.75	.0005
Superfine Finishing	No. definite feed		Material removed				1.0	.0006
Honing	Cross-hatched pattern		.001	.0003	1	8	1.5	.0007
Micro-finish by honing	"		.0002	.0001	.5	4	2.5	.0008
Mechanical lapping	Random path by combined motions		.0003	.00001	.5	4	3.0	.0009
Superfinishing	Random pattern		.00015	.00005	.5	4	4.0	.001
							5.0	.0011
							10.0	.0016
							20.0	.0020

*1 micro-inch (mu inch) = .000001 in. ave.

Fig. 14.—Comparison of Feed, Depth of Cut, Depth of Surface Ridges, and Tolerances for most accurate Holes.

bronze shell, well babbitted with a ring or a wick oiler. Above 800 revolutions antifriction bearings are advisable: a rigid double row taper roller bearing in front and a cylindrical bearing in the rear, to allow free extenson with heat.

However, it might be mentioned that we used in a small diamond turning machine (1½ H.P.) a front bearing of 2½ in. diameter made of a nitrided hard steel shaft in a babbitted plain bronze bearing without wick or ring and oil grooves, lubricated by free drop oiling through the slot on top up to 5,000 revolutions with not more than

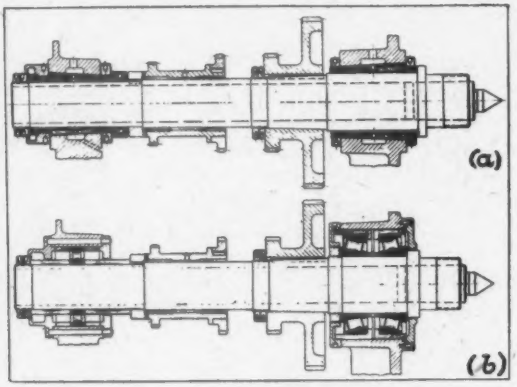


Fig. 15.—Plain versus roller bearings.

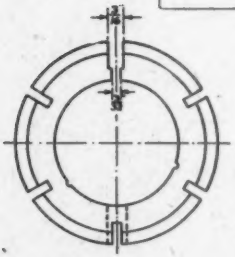
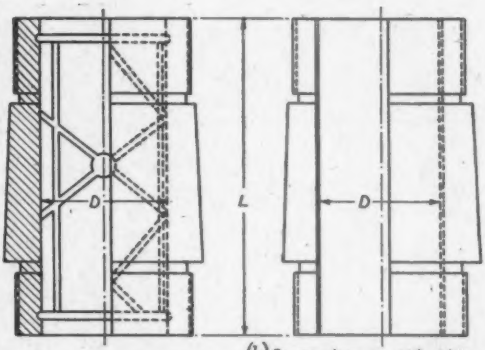


Fig. 16.—(a, b). Front and rear bearings of modern diamond turning lathe.
(a) plain bronze bearings up to 2900 r.p.m.
(b) change to babbitted bearings up to 5000 r.p.m.



(a) Original bronze bearing.
$D_{Front} = 1\frac{7}{8}"$; $L_{Front} = 5"$
$D_{Rear} = 1{\cdot}5"$; $L_{Rear} = 3\frac{1}{2}"$

(b) Bronze bearing with white metal lining for front and rear without oil grooves
$D_{Front} = 1\frac{7}{8}"$
$D_{Rear} = 1{\cdot}5"$

.0004 in. clearance between journal and bearing. Fig. 16 (a) illustrates the bronze bearings with oil grooves as the machine arrived; it ran hot after 20 minutes with 3000 rpm. Fig. 16 (b) shows the babbitted bronze shells without oil grooves replaced by courtesy of the Glacier Metal Co., Ltd., Alperton. The possibility of adjustment for the front and rear bearing by the taper slotted shell

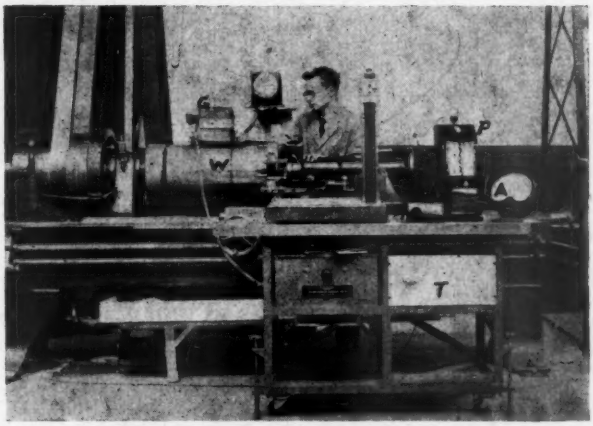


Fig. 17.—Transportable measuring box of Talysurf.

T = Talysurf-Surfacemeter. G = Gearbox with pickup.
P = Pen recorder. A = Averagemeter.
W = Workpiece.

is well proved by experience and foolproof in spite of all theoretical objections.

If heavy pieces, *e.g.*, steel rolls of 16 in. diameter, 4ft. long, Cr-Ni steel of 1.2 tons weight are to be checked regarding surface fineness we must have a surfacemeter which is transportable to the piece and allows checking the surface without removing the piece from the centres. We used the "Talysurf" of Taylor, Taylor & Hobson, Ltd., for this purpose (Fig. 17). The gearbox with pickup is taken from the column and fastened directly to the piece using a shoe resting on three points to guarantee the circle, and clamped by an ordinary bicycle chain.

Average readings and pen records were taken by this method. The whole procedure from taking the pickup from the column, fastening to the specimen, making the measurement and returning it to its place, does not take more than five minutes. This method to check the surface quality produced is much finer than the ordinary

method to check the cutting forces and the dulling effect on the tool. The greatest advantage is that the cutting tool itself is now used rigidly clamped in the ordinary way to the toolpost and not supported on a vibrating diaphragm which impairs the quality of the surface. Such a dynamometer is indispensable to measure the forces, but it is in any case detrimental to the surface quality. A " 66 " material using a cross-section of chip of .008in. deep and .004in. feed with a peripheral speed of approximately 50 f.p.m. had a life of an hour on semi-hard steel of about 40 tons (*cf.* Fig. 13). Within this hour the commercial finish varied between 32 and 44 mu in., fulfilling the working conditions for this surface.

Measuring the surface quality as dulling criterion instead of measuring the increase of the cutting forces is the new but most effective and recommendable procedure for making finishing tests. Further it corresponds to workshop practice. Today the inspector or the foremen decide by sight and touch if the piece of correct dimensions is acceptable for the working conditions in the built-up state. This is valid for running, transition and interference fits. Before we used the surfacemeter for workshop tests of this kind we were obliged to verify if the instrument was insensible against the unavoidable vibrations, shocks and jerking action in the workshop. (The very satisfactory results of such an investigation are published in the report on Surface Finish of the Institution, fig. 145).

New tests taken on the reconditioned lathe on ferrous material : 40 ton semi-hard steel (for locomotive axles) using a cemented carbide tool for 1 hr. 40 mins., then using a similar cemented carbide tool with changed cutting angles for 40 hours on aluminium alloy proved the regularity (pitch) of the finish. The diagram (Fig. 18 (a) shows a prefinished surface of 66 mu in. on steel and Fig. 18 (b) a commercial finish of 27 mu in. using a diamond on a piston skirt of aluminium alloy. Both cuts were made dry. The pen record of the piston is made with 8000 vertical and 150 horizontal magnification—the graph of the steel bar to 2000 vertical and 150 horizontal. Therefore the pen records are distorted ; the upper one with 13 : 1, the lower one with 53 : 1. They are then stretched to natural size—8000 to 8000 and 2000 to 2000. The shape of the 90° point of the tracer diamond is shown in contact with the real shallow curves. This proves that this 90° tracer will never touch the walls of the ridges of the real pen record.

The upper graph shows further the wear of the cemented carbide tool after 1 hr. 40 mins. use when the surface quality was decreased from 45 mu in. in the beginning to 66 mu in. at the end of the pass. Here a magnification of 50 : 1 is used with a projector to show the appearance of the cutting spot of such a worn tool.

A table which gives the connection between speed, material, machineability index, feed, depth, cross section of chip and power

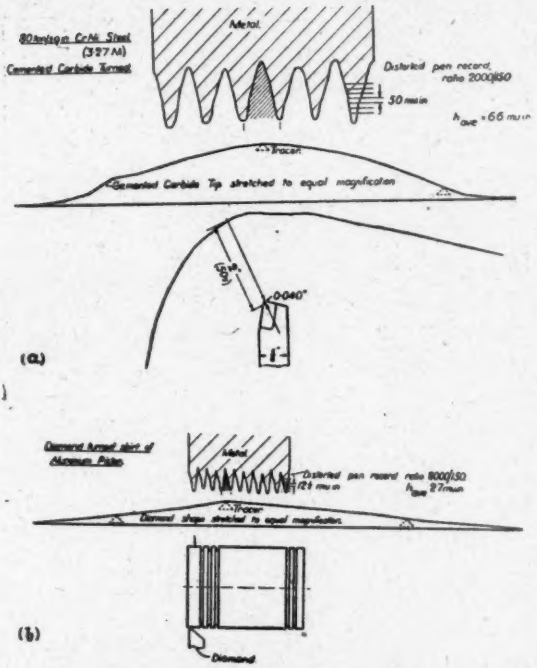


Fig. 18.—(a, b). (a) Prefinished steel surface by cemented carbide tipped tool ; (b) finished aluminium surface by diamond tool.

drive of the existing machine is the practical result of research work for the production people (Fig. 19). Such a chart ought to be given to the ratefixer. The formula which connects the driving power of the motor with cutting force and cutting speed is :

$$\text{Power : h.p. : } N = \frac{\text{Cutting Force} \times \text{Speed ;}}{33{,}000 \times \eta}$$

$$\text{Cutting Force } F = I \times d \times f.$$

Average speeds are for :

(*a*) Cemented carbide : $v = 130$ ft./min.

(*b*) Stellite 80 and SHS (5% Co + 18% W) } $v = 60$,,

Tool		Specimen		Cut	Coefficient $C = \frac{I.v}{21000} = \frac{21000}{254000} \times \frac{1}{v}$	roughing				Cross Section S sq.in.	Drive-Power		Remarks
						constant	variable	Constant	variable				
Mat.	V Speed fpm.	Material	Index lb/sq.in.			f_1 feed in.	d_1 depth in.	f_2 feed in.	d_2 depth in.		Avail-able h.p.	Nec-essary h.p.	
Cemented Carbide	130	No.66 for cutters	254000	roughing	0.00063	.030	.06	.015	.12	.00018	2	$\doteq$ 3	Just exhausted
„	130	„	„	„	„	.030	.10	.015	.20	.00030	5	„ 5	„
„	130	„	„	„	„	.030	.15	.015	.30	.00045	7	„ 7	„
„	130	„	„	„	„	.030	.20	.015	.40	.00060	10	„ 10	„
SHS 5% Co 18%W	60	No.66	254000	„	.00137	.030	.013	.015	.025	.0030	3	2.9	„
	60	„	„	„	„	.030	.023	.015	.045	.0069	5	5	„
	60	„	„	„	„	„	.032	.015	.065	.0096	7	7	„
	60	„	„	„	„	„	.046	.015	.090	.0138	10	10	„
HS 18%W or	40	No.66	254000	„	.0021	.030	.020	.015	.040	.006	3	2.9	„
6%W	40	„	„	„	„	„	.035	.015	.070	.0105	5	5	„
6%Mo	40	„	„	„	„	„	.048	.015	.095	.0144	7	7	„
	40	„	„	„	„	„	.070	.015	.130	.021	10	10	„

Fig. 19.—Exploitation of existing lathes and capstans by different tools.
For the ratefixer.

Diameter of Workpiece ins.	Speed of main spindle n, r.p.m.																						
	6	7.5	9.5	11.8	15.0	19	23.6	30	37.5	47.5	60	75	95	118	150	190	236	300	375	475	600	750	950	1180
½	.785	.98	1.25	1.55	1.97	2.5	3.1	3.93	4.9	6.2	7.9	9.8	12.5	15.5	19.6	25	31	39	49	62	79	98	125	155
¾	1.18	1.47	1.86	2.3	2.95	3.7	4.6	5.9	7.3	9.3	11.8	14.7	18.6	23	29.5	37	46	58	73	93	118	147	186	230
1	1.57	1.96	2.5	3.1	3.9	5.0	6.2	7.8	9.8	12.5	15.7	19.6	25	31	39	50	62	78	98	125	156	196	250	310
2	3.14	3.9	5.0	6.2	7.8	10.0	12.4	15.7	19.6	25	31	39	50	62	78	100	125	156	196	250	310	390	500	620
3	4.7	5.9	7.5	9.3	11.8	15	18.5	23.6	29	37	47	58	75	93	118	150	188	236	290	370	470	590	750	930
4	6.2	7.8	10	12.5	15.7	20	25	31	39	50	62	78	100	125	156	200	250	310	390	500	620	780	1000	1250
5	7.8	9.8	12.5	15.5	20	25	31	39	49	62	78	100	125	155	200	250	310	390	500	620	780	1000	1250	1550
6	9.3	11.8	15	18.5	23.6	30	37	47	59	75	93	118	150	185	236	300	370	470	590	750	930	1180	1500	1850
7	11.0	13.7	17.4	21.6	27.5	35	43	55	69	87	110	137	174	216	275	350	430	550	690	870	1100	1370	1740	2160
8	12.5	15.7	20	25	31	39	50	62	78	100	125	156	200	250	310	400	500	620	780	1000	1250	1570	2000	2500
9	14.1	17.7	22.5	28	35	44	56	71	88	112	141	177	225	280	350	450	560	710	880	1120	1410	1770	2250	2800
10	15.7	20	25	31	39	50	62	78	98	125	156	200	250	310	390	500	620	780	1000	1250	1550	2000	2500	3100
12	18.5	23.6	29	37	47	59	75	93	118	150	185	236	290	370	470	590	750	930	1180	1500	1850	2360	2900	3700
14	22	27.5	35	43	55	69	87	110	137	174	218	275	350	430	550	690	870	1100	1370	1740	2150	2750	3500	4300
16	25	31	39	50	62	78	100	125	157	200	250	310	400	500	620	780	1000	1250	1570	2000	2500	3100	3900	5000
18	28	35	45	56	71	88	112	141	177	225	280	350	450	560	710	880	1120	1410	1770	2250	2800	3500	4500	5600
20	31	39	50	62	78	100	125	157	200	250	310	390	500	620	780	1000	1250	1570	2000	2500	3100	3900	5000	6200
25	39	49	62	77	98	123	155	197	246	310	390	490	620	770	980	1250	1550	1970	2460	3100	3900	4900	6200	7700
30	47	59	75	93	118	150	185	236	290	370	470	590	750	930	1180	1500	1850	2360	2900	3700	4700	5900	7500	9300
36	56	69	87	108	138	175	216	275	344	435	550	690	870	1080	1380	1750	2160	2750	3440	4350	5500	6900	8700	10800
40	62	78	100	125	157	200	250	310	390	500	620	780	1000	1250	1570	2000	2500	3100	3900	5000	6200	7800	10000	12500

Cutting speeds, feet per min. $v \left(= \frac{\pi d n}{12} \right)$

TABLE OF CUTTING SPEEDS FOR VARIOUS DIAMETERS OF WORK PIECE AND SPEEDS OF MAIN SPINDLE.

From the diameter d (in inches) of the work piece (left-hand vertical column) and from the speed n (in revolutions per minute) of the main spindle (upper horizontal row), the cutting speed v (in feet per minute) can be found.

Explanation of shading in table.

	High-speed steel	Tungsten carbide
Thread cutting	15 f.p.m.	30 to 60 f.p.m.
Machining of today	30 to 60 f.p.m.	120 to 300 f.p.m.
Machining in future		> 300 f.p.m.

Fig. 20.—Exploitation of machine tool by operator.

(c) Substitute "66" and HS (18% W) } v = 40 ft./min.

Average efficiency of standard lathes and capstans $\eta \doteq 65\%$.

Machineability Index:

For material (tools): Substitute "66":
$I = 254{,}000$ lb./sq. in.

Feed for: roughing $f_1 = 0.015$ in.
" $f_2 = 0.030$ in.
finishing $f = 0.004$ in.

Depth of cut = d is to be found.

Cross section of cut = d × f (sq. in.).

The depth "d", to be prescribed by the ratefixer can now be tabulated by calculating the constant factors C for the variable speeds v = 130 — 60 — 40 f.p.m. and feeds $f_1 = .030$ in. and $f_2 = .015$ in./rev.

ex formula: $$N = \frac{I \times d \times f \times v}{33000 \times 0.65}$$

$$d = N \times \frac{21000}{254000 \times v} \times \frac{1}{f}$$

$$C_{130} = \frac{21000}{254000 \times 130} = .00063$$

$$C_{60} = \frac{21000}{254000 \times 60} = .00137$$

$$C_{40} = \frac{21000}{254000 \times 40} = .0021$$

Using the existing feeds $f_1 = .015$ in. and $f_2 = .030$ in. as examples, we can develop the table (Fig. 19) to guide the planning and ratefixing department. The following calculation shows how this table is made. First the ratefixer and the operator of the machine must know how, *e.g.*, the lathes could be exploited for the different tools which are in use. For the ordinary carbon tool a speed of approx. 15 feet per min. is advisable and still today often used for thread cutting. For 18% tungsten or substitutes "66" (46) about 30 to 60 f.p.m. is advisable. For Stellite and super high speed cobalt tungsten 60 to 120 f.p.m. is good. For cemented carbides speeds from 120 to 300 f.p.m. should be selected depending on the material—if soft steel or hard and tough Cr-Ni. The future development will be more than 300 f.p.m. These are the steps which are inserted in table Fig. 20. In the vertical column (left side) the diameter in

Fig. 21.—ISA speed standardisation.

inches is inserted. On top are the existing speeds of the lathes in r.p.m. These constant values are the numbers of revolutions of the existing machines. The varying diameters of the piece are given by the drawing. Only the speeds can be changed according to the tool.

It is regrettable that in almost all workshops the speeds given by the revolutions are different for each machine. Therefore the correct pre-setting of the ratefixer is always very difficult—sometimes impossible. The urgent cry for a standardisation of the numbers of revolutions of the different machine tools at least for the groups: lathes, capstans, milling machines, drilling machines, and planers, does come from the workshop not from the designing office and is not only justified but is the demand of the day. It is already accomplished on the Continent including Russia, Italy, France, Germany, Belgium, the Netherlands, Scandinavia, Poland, Czechslovakia and Austria. Simplified tables derived from Fig. 19 ought to be fastened on each machine tool in the workshop and could be handled as follows: The workman takes the diameter from the drawing and the speed from his piece-ticket, according to the kind of cutting tool pre-set by the ratefixer. Following from the left side from the given diameter, *e.g.*, 2 in. dia. horizontally he finds the speed for a cemented carbide tool prescribed by the ratefixer, *e.g.*, 250 f.p.m. Then going vertically up he finds the necessary revs. of his machine; here 475 r.p.m. If the revolutions on the table do not correspond exactly with the chart of his machine he can increase or decrease the number of revs. within the limits of the common ratio of the range of speeds. By increasing he improves his bonus—decreasing he is losing. However, he can equalise the loss of speed by increase of feed, it is true; but he endangers his machine because he increases the cutting forces and this may break a weak tooth. This danger is another important reason to standardise the speeds and feeds for all existing machine tools. The table of standardisation of revolutions (Fig. 21) has been published repeatedly in the last months.* It is the table which was accepted by the I.S.A.—International Federation of National Standards Association—1938 for all their sponsors. It covers all revolutions from 0.2 to 10,000 per minute used for heaviest boring and turning machines of 35 feet diameter, (80 h.p.) to the high speed drilling machines for drills of .04 in. diameter and less (1 h.p.). There is no machine tool, the gear box of which could not be designed according to these speed rules without handicapping the designer but creating the indispensable and invariable basis for the ratefixer with the intention to increase the output of every metal machining workshop to its maximum, because the standard revolutions of the electric motors, both AC and DC are included—they are *framed* (3000—1500—750—375; 1200—1000—

* I.P.E. Journal, Vol. XXI, June, 1942 p. 240.

(a) *Lathe.*

Number of Test	f Constant feed in.	d Depth of cut in.	a Area of chip sq.in.	v Peri speed fpm.	fv Tangent force lb.	I Index 1000 lb/sq.in.
1	.035	.076	.0027	72	660	241
2	.035	.076	.0027	61	645	235
3	.035	.114	.0040	82	1002	249
4	.035	.117	.0041	73	1002	242
5	.035	.158	.0055	85	1380	244
6	.035	.158	.0055	64	1500	266
7	.035	.189	.0066	72	1750	257
8	.035	.267	.0093	74	2250	235
9	.035	.265	.0092	66	2250	238
10	.035	.307	.0108	65	2520	230
					Average	244

(b) *Shaper.*

Number of Test	Number of strokes per min	Length of stroke in.	v Cutting speed fpm.	d × f Depth in. × Feed in.	a Chip section sq. in.	fv Tangent force lb.	I Index 1000 lb/sq.in.
1	12	21.65	33	—	—	—	—
2	,,	,,	,,	.04 × .04	.00158	373	238
3	,,	,,	,,	.08 × .04	.00312	755	242
4	,,	,,	,,	.12 × .04	.0048	1145	244
5	,,	,,	,,	.158 × .04	.0063	1540	245
6	,,	,,	,,	.158 × .05	.0078	1880	239
7	,,	,,	,,	.158 × .06	.0095	2250	238
8	,,	,,	,,	.158 × .08	.0126	3020	242
9	,,	,,	,,	.195 × .08	.0157	3770	241
10	,,	,,	,,	.235 × .08	.0188	4480	238
						Average	242

Machineability Tests on Steel of 32 ton/sq. in. tensile strength made on :

(a) *Lathe* with constant feed (f) and variable depth (d) keeping speed (v) fairly constant.

(b) *Shaper* with constant speed (v) = number of strokes × length of stroke and variable chip section (d × f).

The last column of each table contains for Lathe and Shaper the Machineability Index $I = \frac{Fv}{dxf}$ which is fairly constant for all cross-sections of chips.

Fig. 22.—(a, b). Machineability Index; lathe tests (a); shaper-tests (b).

600—500), in this most important standardisation from the economical standpoint of production.

If we would have tables on the machineability index of the different ordinarily used materials we would have another foundation stone of correct ratefixing. In table Fig. 22 (a), (b), as machineability index the unit pressure per square inch of the cross-section

CENTRE LATHES

Make	Height of centres in.	H.P.	Speeds No.	Speeds r.p.m. values	Common Ratio	Variation from Step to Step
Le Blond	8½	5	6	54 76 112 178 255 375	1.4 –1.6	40 to 60%
Le Blond	6½	3	6	68 100 144 192 284 400	1.4	40%
Le Blond	6½	3	6	200 310 425 585 880 1200	1.4	40%
Le Blond (Toolroom)	6½	3	12	20 28 40 51 80 108 140 194 250 335 435 600	1.25–1.6	25 to 60%
Springfield	10	7	12	14 20 29 41 58 83 96 135 191 268 392 550	1.4	40%
Monarch (Toolroom)	7	7.5	16	12 15 19 25 31 41 52 68 84 110 140 180 225 292 375 487	1.26	26%
Axelson	10	10	24	8 11 16 21 23 27 30 37 43 50 57 66 75 95 100 126 135 167 181 222 256 363 454 609	1.08–1.36	8 to 36%

CAPSTAN AND COMBINATION TURRET LATHES

Make	Bar Capacity in.	H.P.	Speeds No.	Speeds r.p.m. values	Common Ratio	Variation from Step to Step
Jones & Lamson	2½	8	12	20 29 42 60 82 119 169 243 340 489 694 1000	≏ 1.44	44%
Gisholt	2½	10	6	39 62 108 174 310 509	≏ 1.6	60%
Warner & Swasey	2½	7	12	26 34 47 62 81 112 151 198 274 364 475 658	≏ 1.35	35%

Fig. 23.—Speed range of American machines.

of the chip is chosen which seems to be a good parameter to come to reliable and characteristic results. This index depends not only on the material of the specimen, but also on the cross-section of chip (*cf.* Fig. 8 and 22).

The fundamental principles discussed are now applied to a British workshop which has been equipped since January, 1942, to get most modern machines. (Fig. 23). The table covers lathes and capstan lathes only which are driven by motors of 3, 5, 7 and 10 h.p.—strong machines with fairly high manufacturing speeds. The workshop makes only precision tools for the war needs : maximum

quantity combined with high quality. Three kinds of tools were in use : (1) cemented carbide tipped tools, (2) SHS (5% Co, 18% W), and mostly (3) " 66 " substitute replacing the former 18% W steel. 3 different speeds were therefore prescribed. The material to be machined is in this special case almost exclusively " 66 " material for all kinds of cutters, because the factory is making cutting tools. This material is not easily machineable ; but it is fairly uniform and its machineability index is about 254,000 lbs./sq. in. The important cuts are roughing cuts because these tools are all hardened and

STANDARDISED SPEEDS													
Ratio	1	2	3	4	5	6	7	8	9	10	11	12	Range
1.26	75	95	118	150	190	235	300	375	475	600	750	950	$\frac{950}{75} = \frac{12.6}{1}$
„	95	118	150	190	235	300	375	475	600	750	950	1180	$\frac{1180}{95} = \frac{12.6}{1}$
„	118	150	190	235	300	375	475	600	750	950	1180	1500	$\frac{1500}{118} = \frac{12.6}{1}$
1.41	24	34	48	67	95	132	190	265	375	530	750	1050	$\frac{1050}{24} = \frac{44}{1}$
„	34	48	67	95	132	190	265	375	530	750	1050	1500	$\frac{1500}{34} = \frac{44}{1}$
„	67	95	132	190	265	375	530	750	1050	1500	2100	3000	$\frac{3000}{67} = \frac{44}{1}$
1.58	19	30	48	75	118	190	300	475	750	1180	1900	3000	$\frac{3000}{19} = \frac{158}{1}$
„	30	48	75	118	190	300	475	750	1180	1900	3000	4750	$\frac{4750}{30} = \frac{158}{1}$

Fig. 24.—Most used common ratios ; 1.26—1.41—1.58.

ground afterwards and equalising finishing cuts were only taken to reduce the finishing allowance for grinding sharp ; but this is not in question for the pre-setter's table (Fig. 19). The ratefixer is obliged to take the maximum cut possible given by feed and depth. The table shows two feeds, f_1 and f_2 and 2 depths d_1 and d_2 ; they depend on the material allowance that has to be ground after hardening the parts. The mutual change of f and d is done in such a way that the cross-section of chip : $d \times f$ remains the same, therefore the forces are not increased. The ratefixer knows that by taking these maximum or minimum feeds and depths the motors of

3, 5, 7, 10 h.p. are just exhausted. Before the table could be put into use, the machines were checked with regard to the standardisation of speeds. As most of these machines were of American origin it was very interesting to find out whether they were built according to the table of standardisation. Table (Fig. 23) shows manufacturers, height of centres, horse power, number and range of speeds available, common ratio of the geometrical series of speed steps and

		Tools	Carbon, nickel, and nickel-chromium steels				Steel castings	
			22–32 tons per sq. in.	34–44 tons per sq. in.	45–55 tons per sq. in.	Stainless 32–42 tons per sq. in.	Soft; 22–32 tons per sq. in.	Hard; 34–44 tons per sq. in.
Turning	Roughing	High-speed v	150	120	100	85	115	85
		High-speed f	.04–.4	.04–.25	.04–.08	.02–.06	.015–.15	.010–.1
		Supra cobalt v	200	160	130	100	160	120
		Supra cobalt f	.02–.2	.02–.12	.02–.08	.02–.08	.02–.08	.02–.08
		Tungsten carbide v	350	275	220	175	250	150
		Tungsten carbide f	.01–.08	.01–.08	.01–.06	.01–.06	.04	.04
	Finishing	High-speed v	200	175	130	100	150	110
		High-speed f	.005–.01	.005–.01	.005–.01	.005–.01	.010	.010
		Supra cobalt v	250	200	175	130	200	150
		Supra cobalt f	.005–.01	.005–.01	.005–.01	.005–.01	.010	.010
		Tungsten carbide v	575	450	400	275	350	200
		Tungsten carbide f	.005–.01	.005–.01	.005–.01	.005–.01	.010	.010
	Thread cutting	High-speed v	40	30	25	20	25	20
		Supra–cobalt v	60	45	40	30	30	20
	Planing	High-speed v	100	80	50	30	50	40
		High-speed f	.04–.4	.04–.25	.04–.12	.03–.06	.03–.12	.03–.1
		Supra cobalt v	130	110	75	45	80	50
		Supra cobalt f	.04–.4	.04–.25	.04–.12	.03–.06	.03–.12	.03–.08
Drilling and Boring	Twist drill	High-speed v	80	70	60	50	70	50
		High-speed f		f = .01d			f = .01d	
		Supra cobalt v	130	100	80	70	100	70
		Supra cobalt f		f = .01d			f = .01d	
	Boring bar	High-speed v	100	80	70	50	35	25
		High-speed f	.01–.04	.01–.04	.01–.03	.01–.03	.01–.12	.01–.12
		Supra cobalt v	130	110	100	70	70	45
		Supra cobalt f	.01–.04	.01–.04	.01–.03	.01–.03	.01–.12	.01–.12
		Tungsten carbide v	200	175	130	100	130	80
		Tungsten carbide f	.01–.04	.01–.04	.01–.03	.01–.03	.01–.08	.01–.08
	Reamer	High-speed v	60	40	40	30	40	25
		High-speed f	up to .25/rev.	up to .20/rev.	up to .1/rev	up to .1/rev	up to .25/rev	up to .1/rev

(Grinding, milling, gear cutting, etc.). DATA FOR RATEFIXING OFFICE.

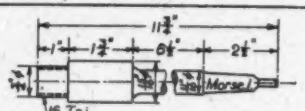
Fig. 25.—Material of parts and

the variation from step to step. The first observation is that these leading American firms reduce the number of speeds on ordinary machines to between 6 to 12. Only a toolroom lathe (Monarch) and one big machine (Axelson) had 16 and 24 speeds. Most of these machines use the common ratios: 1.26, 1.4 and approximately 1.6. They correspond almost exactly to the standardised ratios 1.26—1.41—1.56. They are developed from $\sqrt[10]{10} = \sqrt[3]{2} =$

Cast iron		Bronze		Brass		Light metals	
Soft; Brinell hardness number <180	Hard Brinell hardness number >220	Soft	Hard	Soft	Hard	Soft	Hard
100 .04–.08	85 .04–.08	260 .03–.1	130 .025–.06	350 .015–.18	200 .01–.08	800 .015–.1	600 .012–.08
130 .04–.08	90 .04–.08	350 .04–.08	275 .02–.06	500 .01–.1	300 .01–.06	1600 .01–.08	1200 .01–.06
250 .04–.08	175 .04–.08	600 .04	300 .04	1000 .04	600 .04	3000 .04	2500 .04
130 .010–.015	100 .01–.015	350 .01–.015	200 .01–.015	500 .01	275 .01	1000 .002–.008	800 .002–.008
175 .010–.015	110 .01–.015	500 .005–.01	300 .005–.01	600 .005–.01	500 .005–.01	2000 .003–.008	1600 .005–.008
275 .01–.015	200 .01–.015	1000 .005–.01	500 .005–.015	1300 .005–.01	1000 .005–.01	4000 .003–.008	3000 .005–.008
25	20	50	20	80	40	110	50
40	30	65	30	130	50	175	80
80 .02–.5	50 .02–.5	80 .02–.25	50 .02–.25	130 .01–.15	100 .01–.15	175 .01–.15	130 .01–.15
100 .02–.5	80 .02–.5	100 .02–.25	80 .02–.25	200 .01–.15	150 .01–.15	275 .01–.15	200 .01–.15
$v = \frac{50}{f = .02d}$		$v = \frac{50}{f = .015d}$		600 .015d	175 .01d	1000 .01 d	600
$v = \frac{70}{f = .02d}$		$v = \frac{80}{f = .015d}$		—	—	—	—
50 .01–.2	35 .01–.2	130 .01–.03	60 .01–.03	250 .01–.04	100 .01–.04	800 .004–.04	500 .004–.04
80 .01–.2	60 .01–.2	175 .01–.03	100 .01–.03	350 .01–.04	175 .01–.04	1300 .004–.04	1000 .004–.04
200 .01–.15	100 .01–.15	275 .01–.03	130 .01–.03	500 .01–.04	275 .01–.04	2000 .004–.04	1300 .004–.04
40 up to .25/rev	40 up to .1/rev	40 up to .4/rev	25 up to .2/rev	100 up to .4/rev	75 up to .4/rev	130 up to .4/rev	100 up to .4/rev

v—denotes the speeds in feet per minute and f—the feeds in inches per revolution.

tools; adaption of speeds and feeds.

Operation chart	Description	Reamer 1" ø
	Component	Body
	Numbers per year	1100 + 7% = 1177
	Batch (pieces)	95
	Material	Mild steel 35 tons/sq.in.
	Rough dimensions	1" dia x 11 13/16
	Weight	6.5 lb.

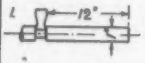
	No.	Operation	Machine	Jig tool gauge	revs per min	Cutting speed f.p.m.	Feed in.	Machining time (minutes) Setting up	Machining	Handling	Delay	Total	Pieces per hour
1 	1	Cutting-off	Circular Saw	Foot rule	500	65	.004	30 S .31 0	.27	.35	.04	.87	69
2a	2a	Centring Counter-boring	Centring machine	Counter sink	750	30	.0015	-	.23	.09			
2b	2b	Drilling	Drilling machine	Drill	800	26	.0015	.10	.11	.09			
								.10	.34	.18	.16	.78	77
3	3	Turning body of reamer	Lathe	Turning tool Snap gauge	870	70	.015	25 S .26 0	.07	.30	.36	1.79	33.5
4 etc.													

Fig. 26.—Master chart of planning department.

1.26 ; $\sqrt{2} = 1.41$; $\sqrt[8]{10} = 1.58$. Ten is the basis of the decimal system ; two of the inch system. The standard table is useful for the metric and the inch system. Only the LeBlond tool-room lathe and the otherwise well-designed Axelson machine have irregular steps. This result is not quite satisfactory regarding the standardised speeds but it shows that there is obviously a trend towards a speed standardisation in the U.S.A.

Another control of lathes, drilling and milling machines of Continental and American origin showed the result (Fig. 24) that for a speed range of 12 steps three common ratios would cover speeds from 24 to 1050, or from 34 to 1500 or from 64 to 3000, all using the most used ratio $1.41 = \sqrt{2}$. Then the range is in all cases 44 : 1. For another series of machines the finer step 1.26 was chosen with the range of 12.6 : 1, finally a coarser ratio 1.58 with a range of 158 : 1. Machines which are to be used for jobbing work must take both big and small diameters. Then a wide range *e.g.*, from 19 to 3,000 (1 : 158) is useful. For workpieces the diameters of which are not very different the designer prefers the step 1.26 (*cf.* tables Fig. 23 with 24). We can easily decide that it is always possible to find a practical way to combine the needs of the users with a very wide elasticity and adaptability of the maker without handicapping his freedom of design.

If all this preparatory work is well done we can elaborate a chart for the ratefixer containing the material of the parts of the tools and the corresponding feeds and speeds (Fig. 25). Further we can improve the table (Fig. 22) to most modern requirements.

If we complete the piece-ticket of the operator by inscribing the kind of tool, the speed and the feed and hand over to him the design of the piece to be machined, containing the material and the dimensions, he knows everything to adjust his machine according to the pre-set conditions. Using these data he can produce the piece in the given time and make a considerable bonus, depending on his intelligence and ability.

If the ratefixing and planning office is well organised and has sufficient staff it is advisable to make charts for each piece for batch and quantity manufacturing showing the operation and times to be allowed (Fig. 26). Then the aim is reached to supply the workshop with all the necessary information for the maximum output, based on practical data avoiding talk, argument and theoretical considerations.

REPORT OF LECTURE MEETING OF THE LUTON, BEDFORD & DISTRICT SECTION OF THE INSTITUTION OF PRODUCTION ENGINEERS, HELD AT LUTON, ON SUNDAY, NOVEMBER 29, 1942.

A LECTURE Meeting of the Luton, Bedford, and District Section of the Institution of Production Engineers was held at the Town Hall, Luton, on Sunday morning, November 29, 1942, at 10 a.m., when Dr. Geo. Schlesinger, Director of Research, I.P.E., was the Lecturer, his subject being "High Speed in the War Time Production Shop."

Mr. J. R. Pearson, M.I.P.E., President of the Section, was in the Chair.

Discussion

PRESIDENT: Gentlemen, we have had a very interesting lecture, we have run a little late, and we want to finish at 12-30 p.m. With this in mind shall we restrict any question to be directly concerned with the lecture. Before putting your question will you be good enough to give your name for recording purposes.

MR. THURSBY: Can the Speaker give us his opinion on the importance of lapping Tungsten Carbide Tools after grinding.

DR. SCHLESINGER: I advise lapping every carbide tool after grinding. Diamond lapping increases the load bearing area of the cutting edge approximately 40%. If you look at the tool through a microscope you will find you have a fine saw made by the emery wheel like this (diagram). If it is lapped it looks like a straight line (diagram). For grinding, the green grit Carborundum wheels are recommended. The diamond wheel should have approximately 3,500 to 4,000 feet per minute surface speed.

MR. TEMPLETON: I would like to ask whether those charts which were shown on the screen are available.

DR. SCHLESINGER: That depends whether the Institution decide to print the paper in the *Journal*.

MR. SMITH: Under present conditions we can vary the structures and conditions of metal. They come within certain Brinell figures, but under present conditions you cannot maintain them, with the result that all those charts then fall down.

DR. SCHLESINGER: A deviation of 10 to 20 points Brinell is allowed on steels and cast iron. The difference in machining is then not of importance—even with a deviation of from 20 to 25 points Brinell, for example 225 instead of 250—there is not much difference for steel and cast iron, but you must keep the analysis fairly accurate. I suppose you are not referring to non-ferrous

materials, but are speaking of machining ferrous materials only? If the diameter of the pieces is not reduced too much, such as this (diagram), the Brinell variation from the outside to the core is generally not more than 5 to 10%, which corresponds to the above mentioned points. However, we had a case where a Chrome Nickel steel roll of 16 in. diameter and 3½% Nickel was reduced to 8 in. diameter and the Brinell hardness was reduced between 15 and 20%, therefore all our tests were wrong. I would recommend you to use the transportable Brinell press and to Brinell each layer before a new cutting is begun. What work are you doing? Shells?

MR. SMITH: We are making hubs for motor wheels.

DR. SCHLESINGER: What diameter?

MR. SMITH: 14 in.

DR. SCHLESINGER: You have trouble with different material?

MR. SMITH: We have a great deal of trouble.

DR. SCHLESINGER: If the material is not uniform within permissible limits you will always have trouble, but in spite of that the ratefixer ought to do his work as if a certain uniformity could be guaranteed to the workman. I had arrangements made in a shop which was making tools of "66" material only, for the Government. At first we had such big differences in the uniformity that we almost intended to drop the supply. To-day the difficulties seem to have been overcome. The "66" material is very good. As it is now replaced by "46" probably similar difficulties will occur. We then changed the firm's own tools, cemented carbides, super high speed steel, 18 tungsten and "66." This could be done because the firm had a certain stock of super high speed steels.

MR. SIMPSON: Does the speaker recommend Cast Iron against High Tensile Steel for butting tips.

DR. SCHLESINGER: Cast iron is not a homogeneous material like steel; therefore it has a damping capacity which is of great advantage in some cases. For finishing cuts the damping capacity of cast iron shanks is of great influence. Therefore for these tipped tools I recommend cast iron shanks. For roughing cuts it is of no importance. The use of fabricated welded design for machine tool frames is on similar lines. The damping capacity of cast iron frames is greater—read the publications of Dr. Tomlinson (N.P.L.) and the German Professor Thum (Darmstadt). In particular Thum has published very good articles in favour of using cast iron frames against fabricated steel. The main point is the correct design for the two different materials.

MR. WALTERS: We are sometimes troubled with Tungsten Carbide tips flaking at the point just beyond the limit of the cutting edge, we have been advised to take cut each way all round tool.

DR. SCHLESINGER: A tool like this? (diagram).

MR. WALTERS made a diagram of the tool.

DR. SCHLESINGER: If a tungsten carbide tip is flaking, the tungsten carbide is badly made and ought to be exchanged for a better grade or make. The nose radius of the corner is of importance and ought not to be less than .010 in.,—it would be better if you made the radius bigger, say .030 in. to .060 in. Have you much back rake?

MR. WALTERS: We have no back rake.

DR. SCHLESINGER: The back rake is of some importance. It depends on the kind of steel. Changes between 0 and 5 degrees may decide the life of the tool. How much top rake angle have you?

MR. WALTERS: 15°.

DR. SCHLESINGER: 15 degrees is plenty. Furthermore, it is of importance to make the corner of the chip breaker of correct radius, like this (diagram).

MR. WILSON: Have you had any experience with the chip breakers which are fixed on the top of the tools.

DR. SCHLESINGER: Yes, but I found them unsatisfactory. They formed flat coils like a clock spring, and suddenly some broke off to fly 3 to 6 feet up into the air. They came down anywhere in the surroundings of the machine which caused them. To be really safe the men on neighbouring machines would have had to wear steel helmets to keep off these very unpleasant hot (100-800 deg. F.) chips. Roughing chips must be treated in a smooth continuous manner, avoiding the additional power consumption generally present with 'external' chip breakers. Make the correct tool with a small chip groove in the right inclination, then the chips flow or break near the cutting edge and you avoid all this unnecessary trouble.

MR. PERRY: Could you give us some of the characteristics of that special drill which will drill files straight off, I understand this drill is made of special material.

DR. SCHLESINGER: Is this absolutely necessary, and if so, what size?

MR. PERRY: 1½ in. diameter hole.

DR. SCHLESINGER: Why not take the diamond crown; that might perforate the file. You can get an impregnated diamond tool like this (diagram) from the Impregnated Diamond Company, Ltd. (Peter Neven) Gloucester. They perforate stones, marble, etc., with these tools. However, steel may cause trouble. Furthermore, there are cemented carbide tipped drills made by Thos. Firth & John Brown, Ltd., and A. C. Wickman, Ltd., for this purpose. It is a difficult problem you have to solve.

A MEMBER OF THE AUDIENCE: May I add a word regarding the last question. The drill referred to is made from a hard steel imported from America. It is made to do the same work as 40/80 Stellite. Stellite below 80 is excellent material.

MR. HALL: Dr. Schlesinger spoke about vibration, I had the same trouble. Do you not think it would be an improvement to super finish the journals.

DR. SCHLESINGER: Super finishing bearings always give much improvement. The load bearing area is improved while the oil is kept very well on the fine surface. Take one of our experiences as an example. We had a diamond turning lathe which should have run at 3,000 r.p.m. journal 2½ in. diameter by approximately 5 in. long. We could not bring this to run safely at 3,000 r.p.m. It seized up after some minutes and stopped the motor. Then we replaced the bronze bearing by a superfinished babbitted bearing without oil grooves, and used a fine lapped nitrided shaft. Now we have it running up to 6,000 r.p.m. The surface quality is 2 mu. in. In another case one of the big automobile manufacturers sent us two 3 in. diameter crankshafts. One was ground and one superfinished. The superfinished shaft did not seize up for a test period of over six months. The other broke down in the beginning during every one or two weeks. Take the ordinary car. For the first 500 miles you are allowed 25 m.p.h., then with your oil and the dust from the road you superfinish the shaft but the clearance is increased and, therefore, the life of the shaft is reduced from, for example, 50,000 to 15,000 miles. Superfinish was begun by Chrysler (Detroit). Chryslers claim that you can have a car from their works and run it straight away at 80 m.p.h. I believe in superfinish. Messrs. Hayward Tyler & Co., in this town make a submersible pump operating a depth of 250 feet with 1,500 r.p.m. using water as lubricant; after introducing the superfinished bearing they had perfect success.

MR. RIGBY: I should like to know what are the Doctor's recommendations as regards the control of tools in use. I believe great trouble is caused generally by the tools being over-run, and I should like to have his recommendations as to how to control a shop. One particular fact I notice, we get a tool from the manufacturers and we say we get 80 parts before we regrind. In only about one case in nine do we get as good results after regrinding as we get in the first case from the manufacturers, we start off with say 80 parts, then the number is variable, sometimes we get 60, but only in about one instance in nine do we get as good results as from the manufacturers. One other classical case, we spend all the time and knowledge we have in a grinding tool for a cylinder, and we

could not get the same result as we can get from a Van Norman Boring Machine with a girl operator, using a Tungsten Carbide Tool. We take the tool out and set it. The girl gets a stone and just see-saws over it, yet she gets the results. We do not get the same results with the scientific method. How do you account for it?

PRESIDENT: This is really two questions, the first one being What would you recommend as regards the good control of tools in the shop?

DR. SCHLESINGER: You really ought to know how many pieces could safely be made with a tool from one grind. If one grind will do, say, 80 to 100 parts, you could give a prescription to the girl on the basis of results. Instruct her to take the tool out after 80 pieces and return it to the tool-room whether the tool is worn or not. This is an old rule. I saw it carried out in the Singer Works in America in 1924. With all their drills the operator is instructed to drill a certain number of pieces and then change the tool. With this system of each tool only being allowed to do so many pieces it means that the tools are always correct and you have a permanent output. 80% of girls work there by prescription, but the moment there is any trouble you generally find she puts her hands in her lap whereas a boy does the tooling. I believe in piece prescription. It means, of course, that you will want at least two or more tools to cover the shift. Find out the maximum capacity (you probably have a tool-room or all-round demonstrator), and you should be able to run every machine up to capacity, but not over it.

A drill may do ten holes more than the prescription, but in the long run you lose ten times over if the tools are not ground at the right time.

PRESIDENT: Question 2. It explodes the theory of the diamond honing tool on this particular cylinder block on a Van Norman Boring Machine, which is an American machine. The girl has no notion how she does it, but she just rubs the tool with a hand hone and she gets better results than the scientists tool gets from a diamond grinding wheel.

DR. SCHLESINGER: The girl does the honing by hand. Most honing tools are made of an abrasive and not of diamond, and it may be that your abrasive was not correctly selected. We know that a good grade of cemented carbide can compete very well with a ground surface.

MR. RIGBY: It is a Tungsten Carbide tool, and on cast iron we take .010 in. per side.

DR. SCHLESINGER: What accuracy is required?

MR. RIGBY: It comes out at .0015 in.

DR. SCHLESINGER: The main thing is that you find the method by which you are satisfied. We go the same way in the Research Department. A systematic change of the tools, speeds, feeds and

depths, and checking the result by measuring the surface quality, then we know the correct procedure. I agree that there are cases where a well made cemented carbide tool beats the diamond cutting tools, but the diamond grinding wheels are such a new tool that we have not sufficient experience. I will only mention one example. We had non-ferrous parts made by Morris Motors, The Austin Motor Co., The Bristol Aeroplane Co., and Rolls Royce, Ltd., manufactured on fine boring machines, partly by diamond cutting tools, partly by cemented carbide tools. Measuring the angles of the diamond tool we found they had no back rake angle and the tools were set above the centre for boring instead of below the centre (diagram). Put the tool 1 to 2 of the diameter below the centre, give it 3 to 5 degrees back rake for non-ferrous material. For cast iron 2 to 3 degrees back rake (diagram) would be sufficient. In some cases, and with some materials, the positive back rake angle ought to be replaced by a negative back rake angle ; for instance, for some cast iron. Do you use coolant ?

MR. RIGBY : Yes.

DR. SCHLESINGER : For cast iron it should be quite a light cooling oil.

PRESIDENT : I regret our time has gone and I cannot accept any more questions. I am going to ask Mr. Carlton Smith to propose a vote of thanks.

MR. CARLTON SMITH : We, the production engineers of Luton and Bedford District, and visitors accord you a very hearty vote of thanks. We are very privileged to have Dr. Schlesinger as our Research Director, and in having him with us today. He believes, like us, in not only keeping abreast, but in forging ahead, and it is only by using the methods explained by Dr. Schlesinger that we shall do this. I am sure we all accord you a very hearty vote of thanks.

DR. SCHLESINGER : I thank you very much, I would ask you to take away with you today the catchword " Research Pays."

The President then declared the Meeting closed.

REPORT OF LECTURE MEETING OF THE YORKSHIRE SECTION OF THE INSTITUTION OF PRODUCTION ENGINEERS, HELD ON 10TH OCTOBER, 1942.

A LECTURE Meeting of the Yorkshire Section of the Institution of Production Engineers was held on October 10, 1942, when Dr. Geo. Schlesinger, Director of Research, I.P.E., was the Lecturer, his subject being " High Speed in the War Time Production Shop."

Discussion

The vote of thanks was proposed by F. S. Legg, Esq., President of the Leeds Association of Engineers, who said: Dr. Schlesinger, Mr. Chairman, Gentlemen; I have great pleasure in proposing a hearty vote of thanks to Dr. Geo. Schlesinger for this most interesting lecture he has given here this afternoon. I am sure that all of us here this afternoon will go away with a great deal to think about in connection with our engineering problems.

I notice Dr. Schlesinger mentioned rate-fixers quite a number of times. I am sure that if there are any here this afternoon they will spend, or they can spend, a really enjoyable week-end thinking over the information Dr. Schlesinger has passed across to them.

I believe that in the great majority of these big shops, the rate-fixers probably work their system from the low-speed lathe, because, from what we hear in general engineering, in some of the large factories the workmen seem to be coming out with fabulous sums—eight, nine, and ten pounds a week. I think, therefore, that the rate-fixer will have to get busy and study what Dr. Schlesinger has said.

Gentlemen, with these few remarks I have great pleasure in proposing a vote of thanks to Dr. Schlesinger.

The vote of thanks was then seconded by F. Grover, Esq. (*Member*) who said: Dr. Schlesinger, Mr. Chairman, Gentlemen: The president was kind enough to give me his confidence in a little conversation we had prior to this meeting, and, as he asked if I would second the vote of thanks as a senior member and an owner of machine tools deemed obsolete today, I feel that there was some hidden meaning; so I should be doubly appreciative of modern tools and I think I fit that bill exactly. I can only say that I agree, sir, heartily with the remarks passed by the proposer.

There is one very interesting feature, the psychological reactions between the workpeople and the rate-fixers, in this matter of working in the workshop and I think that Dr. Schlesinger has touched a human chord in referring to these reactions which are so important because if you do get a dissatisfied worker on a tool, you start a kind of infection in a shop which is very dangerous. I think that a kind of signal has been hoisted here today as a bright red light to the rate-fixers handling.

I am quite certain that to anybody passing over the information we have had today and trying to co-ordinate it during the time of this lecture it is a practically impossible task. We ought to go over these figures, to remember what Dr. Schlesinger has said and try to combine them in our daily experience in the workshop, and if we do that, I think we shall not fail in doing our duty and thanking Dr. Schlesinger for putting before us the information that he has ; and so I have very great pleasure in seconding the vote of thanks.

MR. MCMAHON (*Member*) : Mr. Chairman, Dr. Schlesinger, Gentlemen : In stating the conditions necessary for the best use of the Substitute 66 with the tools we have, Dr. Schlesinger pointed out to us the importance of applying a cutting lubricant to the point of the tool to reduce the abrasive action. Although the speed of the machine may be right, unless the cutting lubricant is applied we are going to have a short life of the tool. I would like Dr. Schlesinger to amplify that.

DR. SCHLESINGER : The correct choice of the lubricant is of great importance on substitute material and on all high speed steel as well. If it is possible, use a lubricant at about 2 to 3 gals./min., about 20 lb./sq. in. pressure on a tool.

The kind of lubricant is not perhaps so very important for the different steels, and you can use a dilution of 1-40 to 1-25 of any of them. You have in this country at least 8 firms which make good solutions which can be used. It must not be diluted too much to form rust, and, of course, the chemical and physiological disadvantages—smelling, skin disease, deterioration in store—have to be avoided. I should say, never cut hard steel dry. The tool life is lengthened from 1 to 3 and the surface quality is improved if you use a good and ample lubricant. Particularly recommendable are the sulphurised cutting oils. The capstans and automatic screw machines are all fitted for lubricants. The older existing lathes must frequently be rebuilt for the use of lubricants, they must have pump, pipes, strainer and first of all a big tray to take a sufficient quantity of oil.

You may be interested in tests done for an affiliated firm which we made on chromium nickel steel 3.5% Ni.) of 80 tons tensile. We tested 66 substitute tools for finishing cuts as follows : .005 in. depth of cut, .002 in. feed at a low speed of 50 ft. per min. The tools stood 7 hrs. 23 mins. and gave a surface of between 100 and 110 micro-inches which could not be accepted as a final finish. The speed was then increased to 109 ft./min.—the tool worked 1 hr. 44 mins. and gave a surface of 32 micro-inches which is a good commercial surface in competition to the grinders. When the speed was reduced to 70 ft./min. the tool worked dry 2 hrs. 16 mins. and we obtained a surface of 42 to 45 micro-inches. This finish was not

accepted by the client. By using a lubricant the finish was improved to 32 micro-inches and the problem was solved.

MR. F. GROVER: From this information just given out; I understand, sir, that a firm can send a proposition to the laboratories, over which you are head, and that you will undertake to supply information such as you have just given out. I would like to emphasize now that it really is an important function, which the research department is undertaking, and I hope it is widely known. They will supply that information which is wanted by people who are undertaking jobs not in their regular line.

DR. SCHLESINGER: We have 3 functions: Firstly, we do work of general public interest according to the plan laid down by the Research Committee of the Institution. Secondly, we do urgent work for various departments of the Ministry of Supply to help the war effort. Thirdly, we do work for private firms in special application.

(1) The Report on Surface Finish is a good example of the work done by the Institution of general interest.

It was financed by the Institution but supported by the close collaboration of 19 leading British firms.

(2) Work for the Government forms a considerable part of our activity, but the results must generally be secret.

(3) Work for private firms which is paid for and can only be published if the client agrees and the Director of the Research Department thinks that the results are worthy of publication. Undesirable propaganda is guarded against by printed regulations which must be acknowledged by the client before the Department accepts the order.

You may remember that old story of the three boot-sellers in the street of London. They each had a poster: the first poster said, "I sell the best boots in the world," the second poster said, "I sell the best boots in London," the third, "I sell the best boots in the street." They all appeared in front of the judge, who gave judgment that the three posters should be removed. The first two were dismissed with the words "Nobody believes that you sell the best boots in the world or London," but, the third man was fined because he was offending the other two.

The Research work on tools of substitute steel alloys, on non-ferrous material, etc., is not secret, in spite of being done for the Ministry of Supply. The same applies to the comparison of surface quality of German and British aero-engines. The results will therefore be published as soon as we have time. This work is financed by the Government. Queries of members, which do not require research work, arrive daily and are answered at once, if we are able to give a satisfactory answer.

It is good to have such an Institution in the country to whom the production people can come to qualify any specific points, and to check the practical application if necessary.

MR. BRADLEY (*Visitor*): With regard to the tipping of tools, say tipping a 2 in. steel shank with 66 substitute, using Stalweld tipping powder, we don't get such good results as when we use the ordinary high speed tip.

DR. SCHLESINGER: I am informed by a tool works which uses this powder that they have no difficulties, if the specification for the treatment is correctly followed. We had some tools in the Research Department, which were tipped with "66" using a kind of brass as brazing medium (melting temperature about 800°C.). Another set had butt-welded tips made by courtesy of Edgar Allen. Both kinds proved equally good, but I prefer the butt-welded tool.

The cemented carbides cannot be butt-welded. Copper or silver brazing is used, to form a kind of elastic joint between the material of the shank and the tip to allow for the different expansions of the metals. This brazing must be done very carefully.

MR. KENYON (*Member*): There were three phases to Dr. Schlesinger's lecture which as one who has been through the P.B.R. stage, I was rather interested in.

I am glad to see that the Doctor is taking a lead in the standardization of speeds in machines. I am sure every rate-fixer present will bless him for his efforts in that field. I would like to know if there is any possibility for machine-tool manufacturers to get more such standardization, or is it just a passing phase?

Secondly, I was interested in the question of the pre-setting of piece-rate times. It is a feature which has come to the fore in recent years, and I find that in going around in my work this year, there is very little appreciation of the pre-setting of piece-rate times. I think one of the main causes of that is due to the large variety of speeds and feeds now in being in the plant in this area. I think it can be overcome by a little intelligent application, and I think we here this afternoon, by a little study and good intelligent investigation amongst employers can help in this. As I look back on my rate-fixer's days, I think of the day when looking down a line of automatic machines you found about 40 machines with about 40 different feeds and speeds.

I know that if Dr. Schlesinger's ambassadorship can push forward the time when speeds and feeds, speeds particularly, will be uniform, then he will have done a useful piece of work.

Another point especially arises, Dr. Schlesinger, and that is the utilization of semi-skilled and female labour. In the present time, one of the chief causes of dissatisfaction, I feel, is in regard to the utilization of semi-skilled labour, which is such an urgent necessity. From the statement that Dr. Schlesinger has made, the dissatis-

faction with regard to piece-rate prices can be traced back to the lack of uniformity in speeds and feeds, with consequent dissatisfaction. I am glad you advocate pre-setting of piece-rates, because I think that the days of the stop-watch for the setting of prices has gone, and it is in that direction that I would like Dr. Schlesinger to develop his theory on the theme of pre-setting for piece-work prices.

DR. SCHLESINGER: It is one of the most important things to have the planning department in good shape, and it should be a rule that not a single piece goes to the shop without having the principal piece-rate pre-set.

Too often the speed and the feed are in the hands of the workmen. Pre-setting is the only reliable way of securing satisfactory output and at the same time a good bonus for the operators. Time-studies refer to the constant factors of the existing equipment: setting-up, handling the tools and the workpiece, lost time and similar things. Speeds and feeds, however, change with the development of better tools. Think of the advantages obtained if machines of the same group: lathes, capstans, milling, boring, grinding machines were to have the same speeds independent of the design of different makes of machines.

I recently saw a pamphlet of a big American lathe maker, making four different sizes of machines with different ranges of revolutions. You ask, desperately, why? Not all machine tool makers are, it is true, stubborn enough to deny that the standardisation of speeds and feeds would destroy the individualism of the designer.

At the International Conference in Paris, 1937, about ten countries including Germany, France, Italy, Russia, Scandinavia, Switzerland, Czechoslavakia, Poland, Belgium and the Netherlands were present; all of them accepted the above-mentioned principles of standardization as correct and useful both for makers and users. They could be easily accepted and introduced in this country too.

CHAIRMAN: Dr. Schlesinger, Gentlemen; I am sure that we could go on listening to Dr. Schlesinger for hours and also discuss his lecture, but time does not allow; so to protect him from your enthusiasm I am going to declare this most interesting meeting closed.

May I add an expression of appreciation to the University authorities for the use of their lecture theatre. Finally I hope we shall meet later in the session for other lectures.

Research Department: Production Engineering Abstracts

(Edited by the Director of Research)

NOTE.—*The addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough.*

ANNEALING, CASEHARDENING, TEMPERING

Plant and Process Problems, by D. G. P. Paterson and J. Bearn. (*Sheet Metal Industries, March, 1943, Vol. 17, No. 191, p. 431, 10 figs.*).

Case hardening. Cyanide case-hardening. A typical example of exfoliation. Free cementite in nickel-chrome case hardening steel hardened in box. Core structure of case hardening mild steel heat treated. Time penetration curve for typical case hardening steel at 950°C. (Cyanide process). Time case-depth curve (nitriding). The nitriding method of case hardening is applied to certain special "Nitralloy" steels containing 0.2 to 0.5% of carbon together with say 1.1% aluminium 1.5% chromium and 0.2 %molybdenum. Properties of nitrided steels.

COOLANT, LUBRICANT.

The Influence of Lubricating Oil Viscosity on Cylinder Wear, by H. A. Everett, S.A.E. (U.S.A.) [*Preprint, War Engineering Prod. Meeting (U.S.A.), January 11-15, 1943*].

Wear of piston rings and cylinder walls is the greatest single item of wear in the modern automotive internal combustion engine. While under normal service conditions such mechanical wear is slight, the process is continuous and is materially influenced by such factors as (a) operative conditions, (b) characteristics of fuels and lubricants and (c) the composition and surface condition of the parts themselves. It has been shown that different lubricating oils have a marked influence on cylinder and ring wear, even though scuffing or seizure does not develop, and these tests were undertaken with the purpose of determining the influence on wear of one single property of the lubricating oil, its viscosity.

Special precautions were taken to eliminate all other variables and the range of viscosities covered was as extensive as compatible with this restriction. Tests were made with six oils ranging from a viscosity lighter than SAE 10 to a viscosity greater than SAE 70.

Each oil was tested in a battery of six single-cylinder engines operating under conditions artificially controlled to simulate closely moderately heavy duty road operation of automobile passenger car engines.

From one result it appears that the cylinder and ring wear in well-lubricated engines decreases progressively with increasing viscosity throughout the range tested, the wear being almost inversely proportional to the kinematic viscosity. This is in harmony with our current understanding of fluid film lubrication as the film thickness for a given loading is probably nearly proportional to the kinematic viscosity and certainly wear is an inverse function of the film thickness. An accurate determination of the character of the lubrication, i.e.,

whether of fluid film or boundary type, cannot be made but the small amount of wear, the smooth surfaces, and the light loading due to ring pressures indicate that through the majority of the reciprocating cycle fluid film action was predominant.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

JIGS AND FIXTURES.

Template Production for Aircraft Tooling, by R. R. Nolan. (*The Tool Engineer (U.S.A.), January, 1943, Vol. XII, No. 1, p. 86, 6 figs.*).

The development of electrolytic etching in aircraft tooling, typifies methods used to solve problems peculiar to the aircraft production engineer. The ideal template duplicating process should possess the following features: 1. Exact scale reproduction; no distortions or widened lines due to optical or contact error. 2. More durable if possible than the scribed original. 3. It should produce a complete template and eliminate costly cutting operations. 4. Process accomplished by semi-skilled labour. 5. Process cheaper to install and maintain than expensive camera equipment. 6. It should produce templates at a much lower cost per square foot than previous methods.

MACHINE ELEMENTS.

Bearings and Bearing Corrosion, by L. Raymond, (J.S.A.E. (U.S.A.) *Vol 50, No. 12, December, 1942, p. 533*).

"Babbitt" bearings have been accepted generally as the preferred bearing metal for by far the great majority of bearing applications due to their low friction characteristics, conformability, embeddability, bonding characteristics, and corrosion resistance. However, under conditions of increased bearing loads and higher oil temperatures, babbitt bearings of conventional design are susceptible to fatigue failure, resulting in breaking out of the bearing metal. In such cases, protection has been sought in bearing metals with improved high-temperature strength characteristics, the bearing alloys resorted to being copper-lead, cadmium-silver, cadmium-nickel, and hardened high lead (98% lead), as well as other high-lead alloys. The most widely used of these newer types of precision bearings has been the copper-lead. A typical proximate analysis of this bearing metal is 65% copper, 35% lead.

Unfortunately such bearings, unlike babbitts are corroded by the products of oil oxidation the lead being dissolved and the remaining copper shell breaking away from the backing.

Data presented in this paper indicate the bearing corrosion problem to be fairly straightforward in that:

1. Corrosion of copper-lead bearings specifically can be reduced by improving the fineness of the microstructure.
2. All bearings appear to be aided greatly by reduction of operating temperatures.
3. Treating the corrodible bearing by special processes, such as indium plating, greatly increases their corrosion resistance.

However, anomalies are cited which indicate that bearing and oil combinations do not behave in relatively the same manner in all engines.

Different types of corrosion may occur in different engines or bearings, or a mechanical or assembly defect, rather than a corrosive oil, may be responsible for bearing failure. The appearance of a bearing frequently fails to indicate the reason for its failure, and more thorough investivation must be made.

In his conclusion the author emphasizes that the field of bearing corrosion still has large unexplored areas.

(Communicated by D.S.R. Ministry of Aircraft Production).

MACHINING, MACHINE TOOLS

Drilling Deep Holes in Magnesium Alloys, by W.W. Gilbert and A.M. Lennie. [*Mechanical Engineering (U.S.A.), December, 1942, Vol. 64, No. 12, p. 877, 16 figs.*].

These experiments were made to determine which type drills and drilling techniques were best suited for deep-hole drilling in magnesium alloys.

1.—Accuracy of drilled holes (a) size, (b) roundness (c) straightness. 2.—Surface finish. 3.—Chip disposal. 4.—Torque and thrust. (a) clogging of chips, (b) binding, undersized hole, (c) binding ; crooked or spiraled holes. Equipment used for experiments. Methods of test. 1.—Cutting speed or revolutions per minute of the drill. 2.—Feed, inches per revolution. 3.—Design of the drill. 4.—Effect of cutting fluids, effect of helix angle, effect of polishing flutes, effect of varying feed. Curves showing torque developed by standard-flute drills with various helix angles. Curves showing torque developed open-fluted by drills with various helix angles. Curves showing relation between torque and depth of drilled hole for various feeds and chisel-edge angles. Drills recommended for use on magnesium alloys (A, shallow-hole drill ; B, deep-hole drill).

Metal Cutting with Abrasive Wheels, by W. B. Heinz. (*Transactions of the A.S.M.E., January, 1943, Vol. 65, No. 1, p. 21, 12 figs.*).

The analytical investigation herewith reported was undertaken in order to determine whether or not the manner in which an abrasive cut off wheel is operated might have an important effect upon the amount of service obtainable during the life of each wheel ; and whether or not the maximum possible cutting rate might also be subject to improvement by better methods of operation.

What is Your Grinding Problem ? (*Machine-Tool Review, January-February 1943, Vol. 31, No. 183, p.21, 6 figs.*).

Chart showing method of designating Norton wheels. Wheel selection Correct and incorrect methods of mounting a grinding wheel on the machine spindle. Correct combination of grain, bonding, material and grain spacing. Diamond dresser costs. Coolant. Unsatisfactory finish. Spoiled work. Low rate of production. Low wheel speed. Too low work speed. Short wheel life. Wheel breakage.

MANUFACTURING METHODS.

Railroad Extend Use of Metallizing. (*The Machinist, London, March 13, 1943, Vol. 86, No. 48, p. 1354, 4 figs.*).

Sprayed metals help to reduce cost of locomotive, car and shop maintenance. Worn parts, often scrapped are reclaimed.

Avro Lancaster, by Wilfred E. Goff. (*Aircraft Production, April, 1943, Vol. V, No. 54, p. 159, 21 figs.*).

Part IV. The undercarriage support beam : final assembly of the complete aircraft.

MATERIALS, MATERIAL TESTING.

Application of the New Cast-Irons, by C. S. Darling. (*Mechanical World, March 26, 1943, Vol. 113, No. 2934, p. 334, 5 figs.*).

The essential features of the high duty cast irons are the improved properties for general use of high strength, toughness, pressure tightness machineability and resistance to shock : and for heat resistance or retention of strength and absence of growth at high temperatures : and for resistance to conditions of erosion in pumps, etc., and abrasion in grinding mills. Effect of nickel additions on resistance to growth of cast iron in superheated steam at 900°F. Comparative growth of plain nickel cast irons in an oxidising (CO) atmosphere held at 1500°F. for 1½ hours.

"GA" Meehanite (as cast)	Tensile strength	56,300 lb.	p.s.i.
	Yield Point	47,200	,,
	Elastic Limit	21,600	,,
	Mod. Elasticity	21,000,000 lb.	

The heat treatment of high duty castings follows two main lines.

(a) for removal of internal stresses (annealing).

(b) on the lines of heat treatment for steel-quenching and drawing.

Magnesium and its Alloys, by C. J. P. Ball. [*Iron Age (U.S.A.), November 26, 1942, Vol. 150, No. 24, p. 54.*].

A general paper giving short accounts of the common methods of production of Mg, effect of alloying constituents (Al, Zn, Mn), mechanical properties, casting and applications.

(*Supplied by British Non-Ferrous Metals*).

Application and Unusual Physical Properties of Synthetic Rubbers, by Otis D. Cole. [*Transactions of the A.S.M.E. (U.S.A.), January, 1943, Vol. 65, No. 1, p. 15, 4 figs.*].

Details concerning Buna S type polymer, adopted by the Rubber Reserve Company for use in tyres and as a general-purpose rubber, are discussed. Some interesting data on the efficiencies of various synthetic rubber compounds at high and low temperatures are shown. Data are also given which indicate that the proper choice of plasticizer is important for compounds to be used for oil-resistant gaskets, sealing rings, and the like.

Bearing Strength of Plastics and Plywood, by James Bond. [*Transactions of the A.S.M.E. (U.S.A.), January, 1943, Vol. 65, No. 1, p. 9, 9 figs.*].

The results of tests carried out under the supervision of Prof. Earl D. Hay, in the materials-testing laboratory of the University of Kansas to determine the bearing strength of commercially available high impact molded and laminated plastic sheets and resinbonded birch plywood. The tests demonstrate the inferiority of plywoods on bearing strength as compared with the reinforced plastics.

New Apparatus for the Non-Destructive Testing of Materials. [*Schweizerische Technische Zeitschrift (Germany) 1942, p. 562.*].

In the X-Ray examination of materials it has been usual to make use of a fluorescent screen. As an alternative the ionisation of the air after passage of the X or Z rays through the specimen can be measured directly by means of a Geiger counter. The latter consists essentially of a condenser contained in a lead tube filled with air at a reduced pressure (.1 atmos.) and connected to a potential difference just below the normal break down value.

A slight initial ionisation of the air in the tube brought about by entry of radiation through a light metal window is rapidly increased by collision and a considerable charge is transmitted to the central electrode which is connected to a string electrometer. After every deflection of this instrument the condenser can discharge through a high resistance shunt and the number of deflections per second is thus a measure of the degree of ionisation to which the counter is exposed.

This ionisation will in turn depend on the weakening effect of the interposed specimen (nature of material and size). By calibrating the instrument with a standard specimen, departure due to internal faults can be found and in this manner cavities in steel at a distance of 30 cm. from the surface have been detected. The instrument is also very useful in examining steel blanks for gear wheels and a special counter (14 mm. diameter) can be inserted inside tubes for rapid testing of consistency of wall structures. It should be noted that the instrument does not only show up flaws but also any difference in wall thickness due to corrosion, etc. This is especially useful in the case of *tank* or boiler installations. Other interesting applications of the counter are in connection with liquid level gauges (weakening effect of liquid on radiation) and automatic control of the powder core of match fuses. In this case the fuse is made to travel past the instrument at a constant rate (80 cm/sec.) Any break of the order of 5 mm. in the core is at once recorded and the motion automatically stopped. The fault is then examined visually on the X ray screen.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

MEASURING METHODS, APPARATUS.

Wear Allowances and Gaugemakers Tolerances, by A. Sprung. (*The Machinist, London, March 13, 1943, Vol. 86, No. 48, p. 1372*).

Plain plug and plain ring inspection gauges including plain ring gauges for major diameter of screws and plain plug gauges for minor diameter of nuts.

Near Allowances and Tolerances for Inspection and Work Gauges, by Frederic S. Wilcox. [*The Tool Engineer, (U.S.A.) January, 1943, Vol. XXII, No. 1, p. 90*].

Gauge sizes. No overlapping. Work limits.

Screw Thread Gauges and Gauging—I and II. (*The Machinist, London, March 27, 1943, Vol. 86, No. 50, p. 1457 and p. 1459, 2 figs.*).

I.—(1) Terms relating to all screw threads. (2) Specifications for American National Form of Thread.

II.—(3) Form of Thread (Standard). (4) Classes of Fit. (5) Gauging Methods. (6) Object of Gauging. (7) Use of Guages. (8) Purpose of " Go " and " Not Go " Gauges.

PLASTIC MATERIAL.

Plugging Porous Castings with Plastic. [*A. Rehbock, Z.V.D.I. (Germany), Vol. 86, No. 7/8, February 21, 1943, p. 126*].

A high degree of gas-tightness is frequently required of castings employed in the construction of refrigeration plant. To ensure this is not always possible as metal castings are frequently permeated with fine pores with the result that it becomes necessary to increase the wall-thickness of the castings to a considerable extent if they are to be rendered adequately gas-tight. Lacquer coatings hitherto used to overcome this difficulty have not always proved satisfactory under actual working conditions. Two processes in this connection have recently been adopted whereby plastic material is used for plugging these porous cavities. This plastic material is applied to the pores of the casting either in the form of a solution or as a liquid which subsequently hardens. The plastic materials most suitable for this purpose are polyvinylchloride and polystyrol.

In the first process an impregnating solution PCU 3 is used. This consists of a solution of Ingelit PCU of a certain grade of polymerisation mixed with suitable solvents. The viscosity and adhesion of this solution are of a consistency required for efficiently sealing up the porous cavities. The impregnation is best carried out in a special impregnating plant, the solution being applied to the pores under suction and pressure. On heating to 80°-90°C. the solvent evaporates. The plastic is resistant to acid and lye as well as to the cooling agents usually employed for refrigeration (with the exception of sulphuric acid and methylchloride).

In the second process monostyrol in thinly liquid state is applied to the pores. This synthetic resin polymerises on heating the casting and applying pressure. The polystyrol thus obtained is for refrigeration purposes still only resistant to ammonia.

(A Rehbock. Paper given at a session of the Committee for the Development of Refrigeration Technique of the V.D.I. in Karlsruhe on November 15, 1941).

(*Communicated by D.S.R. Ministry of Aircraft Production*).

SHOP MANAGEMENT.

Trends in Personnel Management, by Miss E. B. Sharp. (*Labour Management, February—March, 1943, Vol. XXV, No. 266, p. 4*),

Debt to enlightened companies. The underlying principle of co-operation. To-day this principle is accepted. What is personnel management? Definition of international labour office. Do we think too much about organisation and status? The attitude of the Government. The effect of war time legislation. The problem of the uninteresting job. Creating interest in the purpose of production. Growth of team work. A profound interest in and understanding of the individual and his industrial problems are the most important items of success.

Refined Quality Control, by John Gaillard. (*The Machinist, London, March 27, 1943, Vol. 86, No. 50, p. 1430, 2 figs.*).

The quality control chart picks our controllable causes of variation. Often it detects a reduction in quality before it is serious enough to cause rejections. This anticipation of trouble aids in speeding the war effort.

SMALL TOOLS.

Tooling the Turret Lathe, by A. E. Rylander. (*The Tool Engineer, January, 1943, Vol. XII, No. 1, p. 73, 8 figs.*).

This article may be considered educational, treating the conventional jobs the while directing thought to unusual applications. In this connection, the parts shown are "camouflaged" composites of various product designs, a scheme which permits a broader treatment without conflicting with censorship restrictions. Elementary layout showing conventional tool set-up for machining parts. Simple tooling shown in "in line" layout. Layout is designed merely to show beyond normal range of turret and cross-slide. Suggestive float for heavy reamer. Operation sequences are set up to insure maximum accuracy of bore and O.D. with one tool layout, one handling.

Plastic Punches. (*Aircraft Production, April, 1943, Vol. V, No. 54, p. 166, 7 figs.*).

A new development in the form of plastic punches for drop-hammer and hydraulic press tools. Economies in time as well as improved processing are claimed for this new tooling technique.

SURFACE QUALITY, TREATMENT.

Surface Finish of Journals, by R. W. Dayton, H. R. Nelson, and L. H. Milligan. [*Mechanical Engineering (U.S.A.), October, 1942, Vol. 64, No. 10, p. 718, 7 figs.*].

The final finish put on journal surfaces in manufacture is vitally important to their behaviour in severe service, particularly during the critical "breaking-in" period. This paper deals only with the effect of shaft finish on the seizure of plain bearings. It is known that surface finish has an important effect on the seizure of such bearings. More than one degree of smoothness of each type of surface was investigated. The roughness of the surfaces fell in the range of 1.0 to 10 rms microinches as read on a profilometer. The shafts specimens were prepared by Norton Company by commercial methods on commercial machines and are representative of typical journal finishes in industrial use. The seizure tests were made on an Amsler machine. Characteristic friction load curves obtained in seizure tests of rough and smooth shafts. Preliminary tests of steel shafts against four bearing materials : (1) pure silver, (2) copper-lead (28% Pb, 1% Ag, balance Cu), (3) Babbit (7.6% Sb, 3.75% Cu, 0.25% Pb, 88.4% Sn), (4) Bronze (80% Cu, 10% Sn, 10% Pb). Tests of steel specimens with various finishes against copper-lead bearings. Average results for steel specimens are ranged according to excellence as measured by initial seizure load. If each type of finish is considered separately, it is seen that the rougher the surface the lower the seizure load. Conventional profilometer readings will predict the relative seizure resistance of surfaces which are all

finished by one types of operation, but such readings are not very reliable for comparing different types of sufaces. The difference between the final and initial seizure loads is a measure of the ability of the finish to wear-in rapidly to a better surface. Summary. It was found that there was rather good correlation between the seizure results and the product of profilometer readings taken in the axial and circumferential directions. Those surfaces having higher roughness-product readings had greater seizure tendency.

Development of Standards for Army Ordnance Finishes, by Mary Norton. [*Mechanical Engineering (U.S.A.), October, 1942, Vol. 64, No. 10, p. 703, 13 figs.*].

"Ordnance finishes" are those surfaces produced during the final machining of metal components of ordnance material. The following extract from these regulations defines the symbols :—

(g) Requires a coarse grind or file finish for the purpose of smoothing up and improving the appearance of an unmachined surface upon which no stock is to be removed. (cf) requires a coarse machine chipping, or grind finish applicable to clearance cuts or sufaces which are finished to insure the avoidance of interference. (f) requires a machine finish of good quality, applicable to surfaces fitting together but not moving on each other. (ff) requires the finest grade of machine finish. This finish should be used for all ordinary bearing surfaces. (fg) requires a fine grind finish for important steel bearing surfaces and those carrying heavy loads, and includes lapping and polishing where the work requires it. Procedure for standardisation on ordnance finishes. Sample submitted for use in development of ordnance finish standards. Development of ordnance finish standards. Possible limiting sizes of irregularities revealed by different methods of evaluating surface finish. Summary of surface-roughness measurements. Data obtained by measuring finish of samples submitted for development of standards. Formulation of standards for ordnance finishes. In order to give the inspector a simple gauge, it was finally decided to reproduce the desired finishes on a series of flat blocks. Each block corresponds to one of the values given in the table. There are 21 sample pieces representing 7 degrees of surface finish.

TECHNICAL EDUCATION.

A Plus Training System, by F. D. Newbury and P. N. Love. (*The Machinist, London, March 13, 1943, Vol. 86, No. 48, p. 1349, 4 figs.*).

The basis of this programme is entense training on simplified operations for workers without previous industrial experience.

Machine Designing for Fabricated Welded Construction, by F. Koenigsberger. (*Machinery, March 25, 1943, Vol. 62, No. 1589, p. 316, 23 figs.*).

Whilst the designing of a casting is—in most cases—dictated by the necessities of the casting process rather than by reasons of strength, it is possible to apply strength to a fabricated structure just where it is required. The study of the forces, their magnitude and their direction of action, also whether they are applied statically or dynamically, are of vital importance. In a welded construction the permissible stresses depend not only upon the size and shape of sections, but also upon the type of welds and their quality . Consequently

the drawing issued to the welding shop must include all particulars of manufacture. It remains to be decided whether the steel structure should be designed either as a steel casting or as a fabricated structure. In many cases a combination of both is the best solution. Strength and rigidity. The materials mostly used in fabricated construction are 28 to 32 tons per square inch mild steel or steel casting. The rigidity ,which is the decisive factor in most cases, is not much higher for carbon steels or alloy steels than for mild steels, the modulus of elasticity for all these materials being 30,000,000 lb. per square inch within 3% either way. Photo elastic model of a press frame with sharp corners, with modified corners which relieve the stresses. Diagrammatic view of a lathe bed. Chart to facilitate calculating the dimentions of a lathe-bed with regard to stiffness and natural frequency. Chart for finding depth of shears for a lathe-bed. Chart for designing a cantilever when considering shock and static loads. Types of welded joints with expressions for giving the unit stress. Diagram showing how the effective height of a weld can be determined when the member is radiused. Preparation of plates for welding according to L.C.C. welding regulations. Upon the quality of the welds depends the success of the combination of the components which form the actual machine structure. Working stresses for welds. Graphs showing the fatigue strength of butt-welds when variously prepared and treated. Results of static and pulsating loads on welded joints.

The Inspection of Welding, I.—Resistance Spot Welding. (*Institution of Production Engineers, Welding Sub-Committee, Journal Inst. Prod. Eng., December, 1942, Vol. 21, No. 12, p. 492*).

Investigation of relationship between diameter and shear stength of spot welds (20 S.W.G. clean mild steel sheet), with a view to determining safe limit of increase in tip diameter, including an investigation on performance of three types of electrode material.

Welding Fumes from Arc Welding and their Danger to Health. [*G. C. Harold, J. Arm. Soc. Nav. Engs. (U.S.A.), Vol. 54, No. 4, November, 1942, p. 650.*]

In general, potential sources of injury from arc welding other than from trauma and thermal effects seemingly may be grouped in the following categories :—

Oxygen deficiency.
Carbon monoxide.
Nitrous gases.
Ozone.
Metal fume from alloyed steel.
Metal fume from the metal electrodes.
Silica from welding rod coatings.
Harmful substances other than silica in rod castings.
Injurious substances coated on to the metal being welded.
Radiations.
Possible other gases such as cyanides theoretically produced in the electric arc.

From the author's experience and from his appraisal of the literature, it does not appear that the health of arc welders as a class may be set apart as especially different from metal workers in general. Although occasional records of deaths appear associated with some aspect of welding as the cause we have no evidence of any prevailing diseases characteristic of the work of the arc welder (radiation effects excepted).

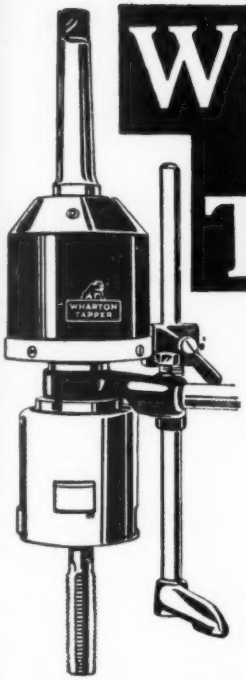
The following ventilation rates when welding with coated electrodes are recommended :—

	C.f.m.
Steel electrodes	
$\frac{5}{32}$ in. or less	250
$\frac{3}{16}$ in.	400
$\frac{1}{4}$ in.	700
$\frac{5}{16}$ in.	1200
$\frac{3}{8}$ in.	1500
Alloy electrodes (fluoride coated)	
$\frac{5}{32}$ in. or less	250
Galvanised plate	
$\frac{5}{32}$ in.	1000—1500

Suitable suction devices connected to local exhaust hoods placed within 8 to 9 inches of the arc with a minimum air velocity of about 125 feet per minute for smaller electrodes are also recommended.

It should be remembered that if the welding is carried out in large open spaces, artificial ventilation will in general not be required.

(*Communicated by D.S.R. Ministry of Aircraft Production*).



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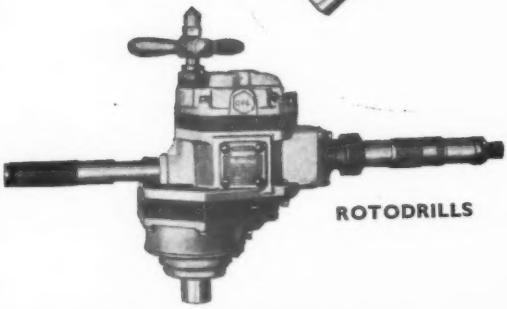

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